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An Augmented Approach To Support Collaborative Distance Learning Of Unified Modeling Language

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Abstract

Teaching in the classroom faces many challenges of providing a collaborative, interactive environment that effectively facilitates students' learning. The challenges increase when the physical classroom converts into a virtual classroom. This difficulty is further exacerbated when the course is diagramming intensive, practice-oriented, and hands-on in nature. Technology has been sought after to help with these challenges. Web Conferencing software, when compared to Web Broadcasting software, can facilitate real-time interaction and collaboration in a distance learning context. For courses that are diagramming intensive and practice-oriented, Tablet PCs, when compared to desktop PCs, can support drawing and diagramming because of the ability to write, sketch, draw, and annotate using electronic ink and drawing tools. These capabilities, when used with Web Conferencing software, add new dimensions to facilitating interaction and collaboration in a virtual classroom. In this research, we examine the use of advanced technologies, specifically Tablet PCs and Web Conferencing software, to support collaborative distance learning of a diagramming intensive and hands-on course – Object-Oriented Systems Analysis and Design (OSAD). The de facto Object-Oriented modeling language, Unified Modeling Language, will be taught in the OSAD course. Our proposed experimental study will examine three conditions or ways of teaching OSAD in a distributed or distance learning context: (i) desktop PCs with Web Broadcasting; (ii) desktop PCs with Web Conferencing; and (iii) Tablet PCs with Web Conferencing. Theories of Media Richness and Media Synchronicity serve as the theoretical foundation for the research.

Keywords: Collaborative learning, Distance learning, Web conferencing, Unified Modeling Language

Introduction

Teaching methodologies continue to adapt to new learning models and approaches. The goal of many of these adaptations is to continually enhance the learning environment and students' learning opportunities. Collaborative learning, for instance, has gained increased attention and importance in its ability to enhance and improve learning achievement. For example, in a meta-analysis performed by Johnson and Johnson (1990), students in a collaborative learning setting outperformed students in competitive and individual settings. Technology can assist in collaborative efforts by providing a rich medium with which communication and information exchange can take place, especially in distributed settings. Technology can help to accommodate new classroom settings that have transformed from traditional face-to-face meetings in one location, to virtual settings over various locations. The popularity of the virtual classroom or distance education courses continues to grow. Greater collaboration and interaction are incorporated into teaching approaches to capitalize on the benefits that these activities can provide in physical and virtual classrooms. It is, therefore, important to understand how technology can be used to enhance and support learning activities in a distributed classroom setting. Furthermore, some courses, such as Object-Oriented Systems Analysis and Design (OSAD), are more challenging to teach because of their diagramming and modeling intensive nature, as well as their orientation toward hands-on and practice that is necessary for students to learn the fundamental concepts and processes to diagram creation. Taxonomies of courses of this nature require sequential steps to be introduced and visualized as each step is dependent upon the previous. The challenges elevate when such courses are taught through distance education programs by the presentation of static diagrams (deliverables of OSAD) rather than having dynamic diagrams created and explained "on the fly". The former approach can impose learning hurdles on students as they attempt to mentally recreate the process of creating the diagrams versus being able to visualize, in *real-time,* the process of creating these diagrams. Hence, the ability to collaborate, interact, and share results in real-time can greatly facilitate teaching of OSAD.

Two technologies to support collaborative distance learning are evaluated in this research – Tablet PCs and Web Conferencing Software. In this research, we will be teaching Unified Modeling Language (UML), the de facto standard for Object Oriented Modeling, in a distance and collaborative learning context. Tablet PCs provide diagramming and pen-based capabilities to sketch, draw, write, and annotate using electronic ink that are absent in desktop PCs. These capabilities are important for teaching diagramming-rich courses such as OSAD and modeling languages such as UML. The use of Web Conferencing software further enhances interactivity in the virtual classroom by facilitating instructor-led interactions and supporting student-to-student collaborations. Thus, the combination of these two technologies can significantly enhance real-time visualization, interaction, and collaboration as well as facilitate instantaneous feedback in a collaborative distance learning setting.

Literature Review

Distance Education

The need for enhancements to the distance learning education experience will continue to grow as the popularity of distance education grows. According to the National Center for Education Statistics, distance learning courses were offered by majority of 2 and 4-year degree-granting institutions (56%) in the 2000-2001 school year, and the number of institutions offering distance courses continued to grow (NCES, 2003). A 2006 Sloan Consortium (Sloan-C) report, *Making the Grade: Online Education in the United States, 2006*, indicates that 3.2 million students were taking online courses in the fall term of 2005. This is a 39 percent increase from the 2.3 million reported in the year 2004 (Allen and Seaman, 2006).

The benefits provided from distance education are endless and include, for example, flexibility, greater convenience to the student, accommodating space constraints, and allowing remote participation. However, concerns also arise with these virtual settings. Some of these concerns include lack of interactivity that was once achieved in the traditional classroom, inabilities to effectively collaborate with peers, and courses that are too difficult to teach and understand without demonstrations and instant feedback. The 2006 Sloan-C report indicates that of the 2,200 college and university responses to a survey conducted, two-thirds of academic leaders cite the need for more discipline (on the part of online students) as a critical barrier to the widespread adoption of online education (Allen and Seaman, 2006).

Research has also acknowledged challenges with distance education. For instance, Conaway et al. (2005) found minimal affective responses and relatively low scores for immediacy (degree of psychological closeness) between students involved with group projects for an online course. Research has shown that immediacy behaviors can influence student motivation and satisfaction (Moore et al., 1996; Christophel and Gorham, 1995). Conaway et al. (2005) suggested that instructors find specific ways to encourage students to contribute to the learning environment. Moore and Kearsley (1996) also cited unique challenges to distance education that include instructors losing the instant reactions and feedback from students, facing challenges of incorporating technology effectively, and providing inadequate structure and motivational support to students. They suggested that one way to overcome this challenge is to allow students to utilize technology. Arbaugh (2000), noting other previous research works, identified concerns of time commitments and human resources to develop and take Internet-based courses, losing face-to-face interaction, and issues regarding the relative quality of learning compared to the traditional classroom environment.

Some suggestions have been made for improving the effectiveness of distance education courses. Moore and Kearsley (1996) suggested that the most effective distance education courses are those that move beyond just presentation of materials, but incorporate three types of interactions: student-to-content, student-to-instructor, and student-to-student. In a distance education course conducted by DaSilva (2003), the biggest challenge that students cited was the distributed nature of the work. The other notable challenge was communication among group members, with some of this attributed to psychological distance. They also noted that although this was a graduate-level computer network course, the students preferred tools that were simple and that they were familiar with. DaSilva (2003) suggested utilizing more robust chat tools and to combine synchronous and asynchronous methods of learning to develop an effective learning community. It is believed that incorporating a variety of opportunities of interaction helps mitigate the psychological distance associated with distance education.

Critical success factors for online education that were identified by Volery and Lord (2000) were:

1) Technology – facilitates interaction amongst students and instructor, appealing and well-structured interface, and easily accessible software that is easy to navigate;
2) Instructor – ability to utilize technology effectively, associate and motivate students, and encourage interaction amongst students;
3) Students' previous use of technology.

In summary, distance education poses unique challenges in facilitating a collaborative and interactive environment. The need for this type of environment is not only important to the physical classroom, but it is also even more critical to the virtual classroom. The use of technology poses potential solutions to these problems. However, the technology will also need to be simple and appealing to use, familiar to students, and readily able to facilitate collaboration. Essentially, the technology needs to fit the objective at hand – collaboration and interaction.

Collaboration and Interaction

The positive impact that collaboration can have has been demonstrated in research studies. For example, Johnson and Johnson (1990) found that students subjected to collaborative learning performed better than those in other kinds of learning environments such as competitive and individualized learning environments. Also, when computer-supported collaborative learning was present, higher achievement scores and more positive learning experiences were obtained (Alavi, 1994; Alavi et al., 1995; Barron, 2000; Boling and Robinson, 1999). Increases in student satisfaction have also been realized in studies by Bligh (1972), Kulik and Kulik (1979), and Benbunan-Fich and Hiltz (1999). Hakkarainen and Sintonen (2002) found students highly engaged in sophisticated knowledge-seeking inquiry within a computer supported collaborative learning environment. When incorporating distant learning as well, Thomas and Carswell (2000) found adequate support for collaboration. In an empirical study of synchronous and asynchronous communication in an on-line environment, Thomas (2002) determined that synchronous systems were most conducive to tasks in which instant feedback was necessary. However, as the complexity of technology grows, the potential learning achievement can decrease. Alavi et al. (2002) discovered that learning outcomes for basic applications (i.e., email) were better than for more complex applications. They construed that as technology grows in complexity, student learning diminishes. Alavi and Yoo (1997) ascribed low evaluation scores for media social presence and course evaluation from distance learning students to issues of limited communication and social presence. Therefore, an effective framework that supports distance education will need to support communication and collaboration among all participants – instructor and students.

Bannon-Ritland (2002) identified interactivity as a critical variable in learning. Lorenzo and Moore (2002, p.4) noted that "Just as in a traditional setting, interaction with classmates, instructors and content makes for effective online learning Interaction is the key". Sims (2003) identified the most prominent themes of communication, engagement, control (allowing users choices of learning directions, but balancing program and learner control), and design (upfront understanding of environment and interactive options) as the major attributes of interactivity, especially in an online learning context. Arbaugh (2000) determined that of the various characteristics affecting student learning in Internet-based MBA courses, only those creating an interactive environment were associated with student learning. Accordingly, achieving an effective learning experience for distance education courses will require technology that supports this interactivity.

Research Question and Objective

In this research, we are interested to identify and assess the use of technology support for instructor-facilitated collaborative learning of *Object-Oriented Analysis & Design* in the distance learning context. *Unified Modeling Language*, the de facto standard for Object Oriented Modeling, will be the modeling language used. More generally, the research objective is to identify and evaluate technologies that can facilitate and enhance the richness and interactivity of collaborative learning processes in the distributed classroom setting for courses that are hands-on and diagramming intensive.

Theoretical/Conceptual Foundation and Hypotheses

Constructivist/Collaborative Learning

Constructivist and collaborative learning approaches have gained much attention in practice and in research. They are well suited and highly relevant to this research because of the hands on and practice-oriented nature of the OSAD course, where students need to explore and conduct self-construction of their knowledge base, and learn from interacting with their peers in project-based activities. Constructivist learning can be interpreted in three different forms (Moshman, 1982). First, endogenous constructivism includes a student's self-discovery of knowledge. Second, exogenous constructivism incorporates an instructor's support in a student's knowledge construction process. Third, dialectical constructivism includes student-to-student interactions. Constructivism, or a cognitive learning model, emphasizes student's self-exploration and learning by their own discoveries and experiences (Leidner and Jarvenpaa, 1995). The collaborative or cooperative learning model, which is related to the cognitive learning model, places learning in the interaction between individuals and recognizes that knowledge is created as it is shared with others. Information technology can be used to create "virtual continuous learning spaces" which allows anytime, anyplace collaborative efforts amongst students.

Mayers' (1995) cognitive psychology based research has pointed out that understanding will be most effective when the task is performed by the learner and that learning is a cycle of this action followed by feedback and reflection. Alavi (1994) has also identified the importance of viewing learning as an active process in which students should be participating in the knowledge construction and acquisition process. Also, cooperation and teamwork can assist considering learning can be viewed as a social process.

Media Richness and Media Synchronicity Theories

According to Media Richness Theory, the richness of a medium is evaluated based on: 1) feedback, 2) multiple cues, 3) language variety, and 4) personal focus (Kahai and Cooper, 2003; Daft et al., 1987). Feedback allows immediate bidirectional communication exchanges. Multiple cues provide for additional channels or cues to be incorporated into the message and may include voice inflection, words, numbers, and graphic symbols. Language variety encompasses the range of meaning that language symbols can communicate (e.g., numbers are more precise than natural language). Personal focus or personalization brings greater meaning to the communication to meet the needs of the receiver. Daft et al. (1987) argued that face-to-face communication are much richer medium than telephone, which would be next in richness, followed by written, addressed documents (e.g., memos) and then unaddressed documents (e.g., standard reports). The theory argues that richer media has more rapid feedback, greater numbers of cues, expanded language variety capacity, and more personalization capabilities. Richer media are better matched to equivocal tasks and media that is less rich is better matched to uncertainty tasks.

However, Dennis and Valacich (1999) pointed out that research has shown unsupportive results for Media Richness Theory predictions and introduced Theory of Media Synchronicity. They contended thatthe focus of Media Richness Theory on task ignores that "fundamental micro-level communication processes" which are common amongst groups and group members regardless of whether a task is equivocal or uncertain. They identified five criteria affecting communication as: 1) immediacy of feedback (enabling rapid feedback), 2) symbol variety (number of ways to communicate information), 3) parallelism (number of simultaneous conversations that can take place), 4) rehearsability (being able to edit the message before sending), and 5) reprocessability (being able to repeatedly process or reexamine the message). Rather than rank ordering media richness, Dennis and Valacich (1999, p. 3) argued that "the 'richest' medium is that which best provides the set of capabilities needed by the situation: the individuals, task, and social context." Therefore, they stated that media synchronicity is the "extent to which individuals work together on the same activity at the same time" and that the "first step is to examine the ability of the media capabilities (immediacy of feedback, symbol variety, parallelism, reprocessability, and rehearsability) to support the two communication processes (conveyance and convergences)" (Dennis and Valacich, 1999, p. 5). Conveyance (exchange of information) and convergence (developing agreed upon meanings for information) are considered necessities for both equivocality and uncertainty tasks.

Based on the constructivist and collaborative learning approach, the technology to support distance and collaborative learning will need to facilitate student-instructor interactions as well as student-student interactions. Also, this technology will not only need to provide students the opportunity to perform the task themselves but also allow them to get instant feedback when they need it, and a record of these activities that they can later reflect upon. The primary focus will be to allow students to learn through their own experiences and self-acquisition of knowledge through their own efforts, as well as their efforts in both the group and instructor-led contexts. The Web Broadcasting software does not support instant feedback and is less interactive than the Web Conferencing software.

Based on Media Richness and Media Synchronicity Theories, distance and collaborative learning will benefit from the medium's ability to provide instant feedback, allow for multiple cues and greater language variety (i.e., symbol variety), allow for personalization (mainly concerning the instructor-student interaction), allow for parallelism (within the classroom, students can work simultaneously on assignments given by the instructor), and offer higher levels of rehearsability and reprocessability (which would allow students to edit before sharing their documents as well as have record of documents to reflect upon). These features are better implemented in the Web Conferencing software than the Web Broadcasting software.

Thus, we hypothesize that:

H1: In a distance learning context, the use of Web Conferencing software will improve students' learning performance over the use of Web Broadcasting software for a hands-on and practice-oriented course.

Tablet PCs, with the pen-based computing support, enables students to more easily diagram UML models. In an OSAD course, learning to diagram is a hands-on and practice-oriented activity. To comprehend the procedures and processes in a diagramming-rich domain, students need to visualize, create, and practice the procedures and processes on their own. Tablet PCs with its pen-based computing feature allows students to take an apprenticeship approach in diagram creation. Tablets PCs, when used in conjunction with Web Conferencing software, allow both instructors and students to share their UML models during classroom discussion. Tablet PCs with Web Conferencing software supports immediate feedback, allows many cues and language variety that can be drawn or typed, enables more personalized interaction, allows students to work simultaneously and share information, and provides the ability to edit/customize and save documents for future use or reflection. Most critical, Tablet PCs, coupled with Web Conferencing software, more effectively facilitates collaboration and interaction. For a hands-on oriented and practice intensive course such as OSAD using UML, instant feedback is considered a necessity to enable the students to visualize the step-by-step procedures involved in creating UML models. Visualizing the procedures versus the final product (diagrams) enhances students' conceptualization of the process and cognitive thought patterns necessary to carry out the required, immediate steps in creating the diagrams. Also, as students are working with other students, a richer information exchange environment is created when other students can watch the design process and provide instant feedback versus waiting until the final product is completed to provide comments.

Additionally, language variety and multiplicity of cues are considered necessary enhancements to diagramming considering that text, diagrams, and notes may be hard for other students to understand and interpret. A richer medium would greatly facilitate the process of discussing, questioning, and clarifying the steps in diagramming. Additionally, when working and collaborating in a group context, students have the abilities to verbally discuss and converse over the diagramming procedures as well as add and share special annotations to these diagrams. Therefore, we hypothesize that:

H2: In a distance learning context, the use of Tablet PCs equipped with Web Conferencing software will improve students' learning performance over the use of traditional desktop PCs equipped with Web Conferencing software for a hands-on and practice-oriented course.

Research Methodology

An experiment is proposed to test the above two hypotheses. The experiment will take place over three semesters in regular OSAD classes. The classes will be conducted in a distance learning setting with scheduled class time. Hence, the students and instructor will meet (virtually) at the same time (synchronous) but in a distributed setting. The same instructor will use the same materials to conduct the OSAD class using UML over three semesters – one semester for each of the three conditions:

(i) Use of desktop PCs equipped with Web Broadcasting software to support the teaching of UML;
(ii) Use of desktop PCs equipped with Web Conferencing software to support the teaching of UML;
(iii) Use of Tablet PCs equipped with Web Conferencing software to support the teaching of UML.

The comparison of students' learning outcomes in (i) and (ii) will be used to test H1 and the comparison of students' learning outcomes in conditions (ii) and (iii) will be used to test H2. Condition (iii) is illustrated in Figure 1. In condition (iii), all three forms of constructivist learning identified by Moshman (1982) can be facilitated: (i) Student's self-discovery of knowledge through exercises and group projects; (ii) Instructor's support in a student's knowledge construction process by the ability of the instructor to provide instant feedback on individual exercises and group projects; (iii) dialectical constructivism, which includes student-to-student and instructor-to-student interactions, by the use of a collaboration software, Microsoft Live Meeting, that is used in conjunction with Tablet PCs to enhance the richness of the interaction.

Figure 1. Configuration for the Full Experimental Condition

Dependent Variables

Four dependent variables will be assessed – (i) improvement in learning achievement; (ii) perceived classroom interactivity; (iii) satisfaction with learning; and (iv) motivation to learn. The first dependent variable, improvement in learning achievement, is assessed by administering a test (pre-test) on UML at the beginning of the semester and another test (post-test) at the end of the semester to measure the students' levels of understanding of UML. Improvement in learning achievement can then be assessed as the difference in the scores of the pre- and post-tests. The second, third and fourth dependent variables – perceived classroom interactivity, satisfaction with learning, and motivation to learn – are perceptual measures that will be captured using both self-reported questionnaires and interviews. Qualitative data gathered via interviews with students will complement and help to interpret the quantitative data obtained from the questionnaires. The questionnaire items for perceived classroom interactivity will be adapted from Siau et al. (2006) whereas those for satisfaction with learning will be adapted from Alavi (1994). The measure for motivation to learn will be adapted from Noe and Schmitt (1986). In addition, the interviews will focus on the students' experience in using technology for learning the course.

Reliability and Validity Issues

As in any field experiment, it is difficult to control all extraneous variables. Demographic information of all students in the three semesters will be captured to assess the key characteristics of the students over the three semesters. Any potential difference in demographics between the students in the different semesters will be controlled in the data analysis. Quantitative and qualitative data will be captured and the data will be triangulated.

Potential Contributions

Based on Media Richness and Media Synchronicity Theories, this research proposes the use of Web Conferencing and pen-based diagramming capabilities to overcome some of the key challenges in teaching modeling intensive and hands-on courses, such as OSAD, in a distance learning context. We anticipate that the combined use of these technologies in a distance education context will provide a richer and more enhanced learning environment that facilitates interactivity in distance learning and contributes to improvement in students' learning performance. Our research will provide theoretical and practical implications for using technology to enhance distance learning of diagramming intensive and hands-on courses.

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