ACHIEVEMENT OF PSYCHOMOTOR SKILLS THROUGH COMPUTER SUPPORTED COLLABORATIVE LEARNING REQUIRING IMMERSIVE PRESENCE (CSCLIP)

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CHAPTER 1.
INTRODUCTION

The use of Distance Learning (DL) to provide education and business instruction is increasing. A recent National Center for Education Statistics (NCES) survey found that over the next three years most higher-educational years to start using or to increase using asynchronous Internet instruction, two-way interactive video, and synchronous Internet instruction (Lewis, Snow et al. 2000). According to the 2000 NCES survey this dramatic increase in distance learning (DL) enrollments in higher education is likely to continue. Many DL studies focus on cognitive skills acquisition (e.g., (Alavi 1994; Webster 1997 ; Daniel 1999; Makkonen 1999)) A few DL studies focus on affective learning (e.g., (Makkonen 1999; Pate 2000; Stocks and Freddolino 2000)). However, DL research that includes cognitive, affective, and psychomotor skills is virtually non-existent. In fact, using DL for psychomotor skill acquisitions acquisition has been viewed as impossible. For example, Newton (Newton 1999) states, "*Psychomotor learning is .... outside the domain of online distant learning.*" This dissertation describes a learning environment that enables the development of cognitive, affective, <u>and</u> psychomotor skills, referred to as Computer Supported Collaborative Learning requiring Immersive Presence (CSCLIP). Chapter 1 begins with a brief description of how distance education has evolved into eLearning. It defines CSCLIP and the problem domain. It then presents possible solutions and the research objectives. Chapter 2 provides an extensive literature review that includes studies from computer-aided instruction, collaborative learning systems, and immersive presence systems. It also discusses the building blocks from previously developed systems, that when combined, create the CSCLIP environment.

Chapter 3 explores and then summarizes the various theories that have been used to inform CSCLIP. Chapter 4 attempts to explicate a CSCLIP theory. Key constructs are identified and operationalized and a framework for hypotheses development is discussed. Chapter 5 examines a CSCLIP laboratory (lab) currently under development. Chapter 6 describes the research method used for empirical testing. Chapter 7 reports on the collected data and discusses the results and implications. Chapter 8 concludes the dissertation with a summary of the findings and future areas of research.

1.1 Background

Over the past century, distance education (DE) has evolved through several generations (Moore 1996). DE has been in existence since the nineteenth century in the form of correspondence courses (Sherron 1997). DE at its most basic level focuses on content delivery to individual remote students to accomplish cognitive learning objectives at different times and different places (DT/DP) (Bloom 1956; Mason 1989; Cleveland 1994; Dede 1996; Sherron 1997). The introduction of the computer in the 1960's and 1970's led to the development of the basic drill and practice Computer Aided Instruction (CAI) (Daniel 1999). CAI migrated from mainframe computing in the early days to networking technologies during the 1990's. At about the same time that CAI was under development, educators also began to experiment with broadcast and recorded media to provide resources for students who were geographically disbursed. As the technologies of CAI, broadcast, and recorded media began to converge, new theories of learning were developed, focusing on the social construction of knowledge and a more "learner centered" approach to instruction (Peraya 1994). As a result, Distance Learning (DL) replaced the term DE.

1.2 eLearning Defined

Through the use of information and telecommunications technology DL evolved to encompass a number of methods ranging from simple downloading of textual content to sophisticated streaming digital video (Brackett 1998; Aniebona 2000; Lawless 2000). Research and practice have moved computer-supported learning into various modes of place and time. DT/DP has been the dominant form of DL until recently. Even some of today's sophisticated environments, such as Asynchronous Learning Networks (ALNs) still employ the DT/DP mode (Hiltz 1997). Alternatively, Group Support Systems (GSS) have been employed for Same-Time/Same-Place (ST/SP), Same-Time/Different-Place (ST/DP) and DT/DP modes (Tyran 1998). Real-time and stored-digital video have also led to the use of additional modes (Brackett 1998; Johannsen 2000). Today this broad range of technologies that allows educators and students to communicate through both synchronous and asynchronous audio, video, text, and/or graphics in a hypermedia environment typically using a web browser is referred to as eLearning (http://elearning.inst.cl.uh.edu/elearning/whatiselearning.html).

1.3 Computer Supported Collaborative Learning requiring Immersive Presence (CSCLIP) Defined

The focus of eLearning thus far has been on cognitive and affective outcomes. Lab coursework has become a limiting factor in the growth of DL opportunities because available technologies are insufficient for educational modules that require hands-on experience with equipment in a group setting. What is needed is a synergistic integration of technologies and Human Computer Interface (HCI) principles from Computer Supported Collaborative Learning (CSCL), group learning systems, and immersive presence technologies to enable achievement of psychomotor learning objectives. In the present study this specific eLearning domain is referred to as Computer Supported Collaborative Learning requiring Immersive Presence (CSCLIP). Having defined CSCLIP, the next section classifies it along three different dimensions.

1.4 A Typology For CSCLIP Learning Environments

There are several dimensions along which learning environments can be categorized including temporal, spatial, and learning objectives. DeSanctis and Gallupe's (DeSanctis 1987) 2 by 2 framework for Group Support Systems (GSS) has been applied to understanding IT usage in learning environments. While this framework enables one to classify learning settings along dimensions of space and time, it does little to improve our understanding of the technologies required to support psychomotor learning objectives in lab settings. An extension of the DeSanctis and Gallupe (DeSanctis 1987) framework by the addition of a third dimension of learning objectives to explain cognitive, affective, and, psychomotor requirements for a lab environment and differences between and co-located and distributed settings is proposed here.

Figure 1 presents a typology of learning environments along the three dimensions of temporal, spatial, and learning objectives. For example, the typology illustrates that the presence required in a traditional lab setting demands ST/SP interactions. CSCLIP represents the use of IT to extend lab settings to support ST/DP interactions while maintaining the same level of presence and support for psychomotor learning objectives. Lab activities can also be conducted in a Different-Time/Same-Place (DT/SP) setting through the use of sequential experiments. As technology improves, some lab experiences are being offered in a DT/DP format through the use of video, computer models, and simulations (Hites 1999; Duarte 2002). The focus of CSCLIP is to support lab courses that require group collaboration at a distance in the STDP mode. Examples of such experiments include manipulating and controlling equipment, assembling and connecting components, disassembling components, and effective communication with other group members.

While classifying learning dimensions in terms of time and space is insightful, it is important to consider the third dimension of learning objectives. This helps to fully understand how CSCLIP differs from existing systems.

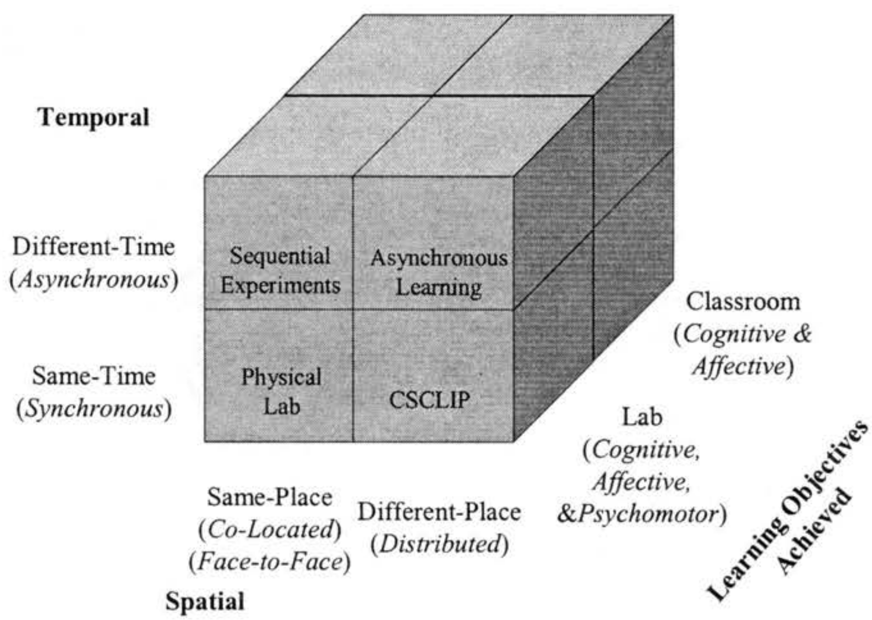

Figure 1. A typology of learning environments and research modes

1.5 Problem Significance

Lab coursework, defined herein to include learning of psychomotor, cognitive, and affective skills, has become a limiting factor in the growth of DL. Current instructional development knowledge and information technologies are insufficient to support learning modules that employ hands-on DL with equipment in group settings. A technology-based system is being developed at Oklahoma State University (OSU) to support the DL capabilities of its highly successful Master of Science in Telecommunications Management (MSTM) program (www.mstm.okstate.edu). Most required MSTM coursework is delivered through a combination of Web and video technologies, however, the program requires all students to travel to OSU to participate in a hands-on lab on the use of technical equipment for various aspects of voice, video, and data networking. The goal of the lab is to ground in reality the learning previously obtained in several theory-based lecture courses, to familiarize students with telecommunications equipment, and to enlighten them about challenges that technicians face. Even though feedback on the lab course is highly favorable, the need to travel to a common site is often viewed as undesirable and may be the reason that some students do not to enroll in the program and either go elsewhere to pursue their degree or not enroll in any program.

1.6 Possible Technical Solutions

DT/DP technology has been employed as one possible solution to the problem facing the MSTM lab course (Scheets 2002). In this case, a remote student logs onto a server using a Web browser to interact with the equipment at possibly a different place and different time than other students also participating in the lab. These types of systems have been used successfully by Cisco Systems E-Learning Remote Labs, Mentor Technologies vLab System, and the Rice University Virtual Lab in Statistics (Lane 2000;

Cisco 2001; MentorLabs 2001). While these labs provide readily available training, they do not provide the collaborative atmosphere of a ST/SP lab.

CSCLIP is a theory-driven system that enables lab coursework to take place in a group setting. Sharda et al. (Sharda 2002) argue that the lack of opportunity to interact with lab mates and the instructor limits the richness and effectiveness of the learning experience. Similarly, Leigh et al. (Leigh 2000) at the National Center for Supercomputing Applications have also attempted to improve existing applications through tele-immersions, which they define as the integration of audio and video conferencing with collaborative Virtual Reality (VR). With continued advances in wide area and last mile communications and other integrated technologies, there is much promise for making a virtual lab experience as effective as a face-to-face (F2F) interaction (Scheets 2002). Continued improvements in technologies such as Digital Subscriber Line (DSL) and cable modems have enabled support for audio and video,so that the interactions necessary for a ST/DP lab, are possible. This technology enables the capture of most of the relevant activities of a lab experience in a remote desktop interaction. Possible activities include interacting with peers, other remote students, and those working in the physical laboratory at the same time, as well as with laboratory hardware and software.

The concepts of CSCLIP do not require students to be co-located to participate in a lab setting. It also allows for more students to participate at the same time, thus increasing instructor efficiency and effectiveness. This provides the MSTM program the potential for growth and new opportunities across the United States and even throughout the world.

1.7 Research Objectives

The objective of this dissertation is to apply CSCLIP concepts in a telecom domain that enables the development of psychomotor skills in a distributed environment and then test to see if these can be transferred and duplicated in a real lab situation. eLearning environments have previously been used to train operators in the use of various kinds of equipment, where initial training in a virtual environment can avoid the expense, danger, and problems of monitoring and control associated with training in real-life situations (Weiss 1998). For example, eLearning can be used to train individuals to perform tasks in dangerous situations and hostile environments, such as in radioactive emergencies or icy road conditions (Weiss 1998). While these systems show great promise for saving time and money, they have been largely untested to make certain they are technically feasible or that the desired skills transfer to real world situations.

As part of the present study, an extensive literature review was conducted which identified a number of other CSCLIP-type systems. The results of this were presented at the 36th Hawaii International Conference on System Sciences (HICSS). The objective was to report on educational uses of the intersection of Computer-Supported Learning Systems, Collaborative Systems, and Immersive Presence Systems (Lucca 2003). When integrated, these systems can support higher-order learning objectives that have typically required co-located interactions. A major finding was that so far, more effort has been spent on the development of new equipment and software than on the evaluation of whether VR related technology helps students to accomplish learning objectives (Weiss 1998). It is important that this disparity be addressed. Darken et al. (Darken 1998) call for standardized methods of evaluation to be developed and systematic data collection protocols to be implemented. Specific areas of importance include feasibility in terms of quality of service, cost effectiveness, and the accuracy, speed, and ease of use of new applications. This dissertation addresses several of these issues as well as the learning domains for achievement of psychomotor learning objectives, the evolution of CSCLIP technology, and its related theory. A typology for CSCLIP learning environments, and a virtual telecommunications lab under development are presented. A theory and research framework for the study of CSCLIP is developed, and a research methodology for the empirical testing of the CSCLIP lab environment to measure cognitive, affective, and psychomotor learning outcomes is discussed. The analysis and results of these outcomes is also presented.

CHAPTER 2.
LITERATURE REVIEW

In this section relevant literature addressing the changes in computer technology and the changes in the learning objectives they support are discussed.

2.1 Computer Aided Instruction/Distance Learning

The introduction of the computer in the 1960's and 1970's led to the development of the basic drill and practice Computer Aided Instruction (CAI) (Daniel 1999). Because of the wide spread use of computers, teaching people to use and program computers has become a major educational activity. CAI systems have contributed significantly to the use of computers in education as well as in the workplace. However, they traditionally focus on individual learners working on a local computer to accomplish cognitive learning objectives (Bloom 1956). DL, at its most basic level, is an extension of CAI to enable remote students to access course content (Mason 1989; Cleveland 1994; Dede 1996). Several different technologies and methods, ranging from simple downloading of textual content to sophisticated streaming digital video have been employed for DL (Brackett 1998; Aniebona 2000; Lawless 2000). Traditional DL still focuses on content delivery to individual students to accomplish cognitive learning objectives (Bloom 1956; Mason 1989; Sherron 1997; Passerini 2000; Piccoli 2001; Benbunan-Fich 2002; Dean 2002; Hunter 2002; Notar 2002). With the deployment of Internet and Web browser technology, a new strategy, Web Based Instruction (WBI), was developed to use these technologies for educational purposes. WBI is often used solely for distribution of course material that allows learning to take place in a DT/DP setting (Belanger 2000). It is typically used to supplement cognitive learning in regular courses and employs the use of File Transfer Protocol (FTP), email, and chat. WBI systems are extensively used at universities and colleges, especially at the graduate level (Kearsley 2000). This is partly due to the low cost and availability of computers and network access and partly due to usage by mature, motivated students who are capable of working independently.

2.2 Collaborative Learning Systems

In the late 1980's the focus of learning began to shift from individual drill and practice to more group interaction with a focus on both cognitive and affective learning outcomes. There was also a shift in the instructor's role from a "*sage on the stage*" to a "*guide on the side*" (Stinson 1996).

Work in the area of non-traditional learning environments, Asynchronous Learning Networks (ALN), began around this time. In a traditional classroom, interaction takes place by speaking and listening (Hiltz 1994). In an ALN, interaction takes place asynchronously through communication with the instructor and other students. The communication messages are stored on the computer waiting to be retrieved by each participant. This means that the temporal dimension is different from the ST/SP traditional classroom and is now DT/DP. This type of system has been effective at supporting "cooperative work". Cooperative-based learning takes place when group members share the workload by addressing separate problem components. For example in a "cooperation-based" learning activity, team members would independently write four separate sections of a paper, and perhaps work more closely together to write an introduction and conclusion. For some students, this type of interaction takes some time to get used to. Hiltz (Hiltz 1994; Hiltz 1997) and others, however, have shown that this type of learning can be very effective because every participant may contribute at the times, places, and rate that is most convenient for him or her.

In the mid 1990s we began to see the change toward more collaborative learning environments wherein group members develop shared meanings about their work, and work jointly as a unit on the problem, learning together and from one another (Anderson 1995; Webb 1996; Brandon 1999). While in a "*collaboration-based*" learning activity, team members would develop a single unified paper to represent their shared reasoning and conclusions (Brandon 1999).

The combination of technology and collaborative learning helps promote learners to use higher-order cognitive skills (Davidson 1995). Group work is encouraged because each participant's area of expertise and past experiences is different and each member makes a unique contribution giving the group a more holistic view of a problem that is meaningful to them. *"For effective learning to take place, learning must be within an authentic, meaningful, situation where experience and knowledge are shared and adapted collectively. Learning is intricately tied to its social environment and viewed as an interactive, constantly evolving process as new information is perceived, evaluated, and integrated into the learner's cognition."* (Davidson 1995)

Collaborative Systems are often referred to by the all-encompassing term "GroupWare", coined by MIS researchers Paul and Trudy Johnson-Lenz Circa 1980 (Johnson-Lenz 1980). Collaborative systems can range from email, to online discussion groups and Internet chat rooms to sophisticated Group Decision Support Systems (Johansen 1988; Coleman 1995). The majority of the research into the use of GSS for education has involved ST/SP classroom situations (Tyran 1998). Alavi (Alavi 1994) argues that effective use of IT in the curriculum and classroom requires a departure from traditional instruction so that they become pedagogically superior and not a solution in search of a problem.

Tyran (Tyran 1997) contends that new teaching strategies will be needed to fully exploit new advances in technology. Some key factors that contribute to effective learning using GSS include active involvement through participation, an open and cooperative climate that encourages the presentation of diverse viewpoints, and frequent feedback. McKeachie (McKeachie 1986) found that lectures are better for lower-level cognitive skills, such as information acquisition, while discussion and collaboration are more effective in retention of higher-order cognitive learning. Advantages of GSS-supported learning include increased synergy, increased participation, promotion of individual accountability, and encouragement of students to help each other. This type of learning environment also enhances student satisfaction with the learning experience, which is useful in invoking the learner's full participation (Alavi 1994; Walsh 1996).

Learners continue to be empowered by technological advances using the social distribution of cognition (Daradoumis 2003). Computer Supported Collaborative Learning (CSCL) is a subset of the wider area of research in Computer Supported Collaborative Work (CSCW) (Hsiao 2001). CSCW is defined as a computer-based network system that supports group work in a common task and provides a shared interface for groups to work with (Ellis 1991). CSCW tends to focus on how things are communicated and is used mainly in the work environment. CSCL on the other hand, focuses on what is being communicated and is used primarily in educational environments. The purpose of CSCW is to facilitate group communication and productivity, while the purpose of CSCL is to scaffold or support students in learning together effectively. CSCL can be synchronous or asynchronous and supports activities such as the communication of ideas, accessing information, and providing feedback in problem based learning.

This body of literature adds insight to CSCLIP in that it provides the foundation for instructional design. Technology alone does not enable collaborative learning. It must be meaningful, take place in an environment that supports participation, and provide feedback to the users.

2.3 Immersive Presence Systems

Advances in networking technology and processing power coupled with decreasing costs in desktop audio and video equipment have led to the emergence of Immersive Presence (IP) systems commonly referred to as VR (Slater 2000; Fisher 2001). Slater et al. (Slater 2000) define immersion as "*an objective description of what any particular system does provide. Presence is a state of consciousness, the (psychological) sense of being in the virtual environment, and corresponding modes of behavior.*" Slater and Wilbur (Slater 1997) elaborate on this and argue that immersion can be assessed independent of presence by the characteristics of technology. Immersion may lead to presence i.e., a participant's psychological sense of "*being there*", but it is a necessary rather than a sufficient condition for presence (Slater 2000). Succinctly put, immersion is wholly a product of the system, while presence is wholly a product of the subject's psychology (Blake 2000). Lombard and Ditton (Lombard 1997) extend the concept of *"being there"* which includes the idea of transportation. They identify three distinct types of transportation:" *"You are there,"* whereby the user is transported to another place; *"It is here,"* in which another place and the objects within it are transported to the user; and *"We are together,"* in which two (or more) communicators are transported together to a place that they share" (Lombard 1997).

The IP user interfaces available today run along a continuum from highly rich and immersive to the much leaner medium of desktop videoconferencing down to text-based interactive communication. At the high cost end is the Cave Automatic Virtual Environment CAVE) (Roussos 1999). CAVE is a VR system with a rear projected 10 foot-cubed room display and stereoscopic images, creating the illusion that 3D objects appear to co-exist with the user in the room. In the middle is PC technology using Virtual Reality Markup Language (VRML) and multimedia technology. Finally, text can be considered as being immersive such that one is "immersed" in a good book (Gerrig 1993). To summarize, there is a wide range of technologies available that enable IP. It is important that CSCLIP users have a sense of being in the lab, but at a reasonable cost. In the next section we look at existing technologies that can be combined to create a CSCLIP environment.

2.4 Building Blocks of CSCLIP

In this section, CSCLIP is related to existing learning systems. The idea of employing computer systems to facilitate both individual and team-based learning has been around since the 1940's, when Vannevar Bush described his famous "*Memex*" (Bush 1945). Over the past four decades researchers, educators, and corporate trainers from many varied disciplines have explored using computer systems in teaching and learning and several areas of research and practice have emerged. More recently many universities have begun to offer full degree programs online through distance education (Mason 1989; Cleveland 1994; Kaye 1995; Dede 1996; Lewis, Snow et al. 2000).

A literature review in this area revealed that three types of computer-based systems are have been employed individually and in pairs to achieve various DL objectives: Computer-Supported Learning Systems, Collaborative Systems, and Immersive Presence Systems. Each of these systems has evolved independently with researchers and practitioners from several disciplines making great strides toward the use of the computer to "*augment*" the human intellect (Engelbart 1963). When two of these systems are integrated, higher-order learning objectives may be achieved. It is asserted that integrating all three will enable learning objectives to be supported in a DL context that have typically required co-located interactions to be supported in a DL context.

We next look at each system in paired combinations. The first combination, the intersection of computer-supported learning systems and collaborative systems, illustrates many systems that have emerged from this integration. See Figure 2. DL has been extended in multiple disciplines through the integration of collaborative learning and information technology, which is commonly referred to Computer-Supported Collaborative Learning (CSCL) (Anderson 1995). A number of MIS researchers have used Group Support Systems (GSS) in the classroom to enhance learning (Tyran 1997; Tyran 1998), while others in IS and related fields have developed Asynchronous Learning Networks (ALNs) (Hiltz 1997; Benbunan-Fich 1998; Coppola 2001; Hardless 2001; Benbunan-Fich 2002; Dufner 2002). Combinations of these two system types have enabled affective learning objectives related to interactive communication and teamwork to be achieved, in addition to more traditional cognitive learning objectives.

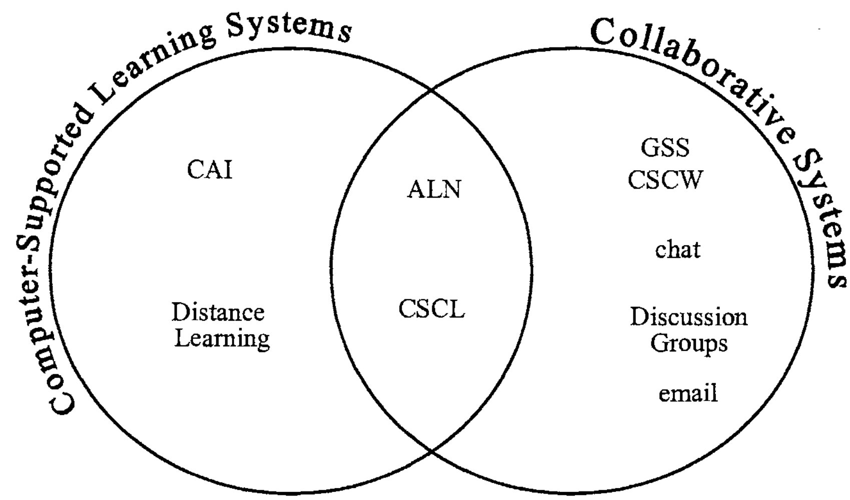

Figure 2. The intersection of computer-supported learning and collaborative systems

The second combination, the integration of computer-supported learning systems and immersive systems illustrates many systems of virtual learning environments that have resulted from their integration. See Figure 3. Several researchers have explored virtual classrooms (Hiltz 1993; Hiltz 1994; Neal 1997). Others have explored using video teleconferencing or streaming video to present lectures via the web or on CD-ROM to remote students (Price 1991; Brackett 1998; Johannsen 2000).

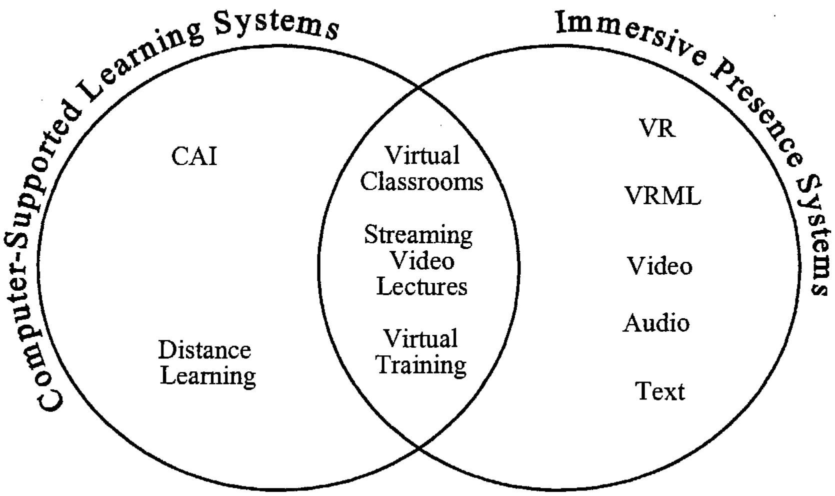

Figure 3. The intersection of computer supported learning systems and immersive presence systems

The third combination, the intersection of immersive presence and collaborative systems, falls into three categories: i) entertainment, ii) simulation and iii) visualization (Monnet 1995 in Takatalo 2002). See Figure 4. Multi User Domains (MUDs), which were originally designed to facilitate action-packed adventure games *Doom* and *Dungeons and Dragons* on the Internet, form the first category (Singhal 1999). Later a new MUD-system was developed called MOO (MUD Object Oriented) where participants create virtual 'selves' and 'lives' using text and interact with other participants in this virtual world in real-time sometimes over an extended period of time, leading to long-term relationships. Simulations, widely used in the area of Virtual Training (VT), for military purposes (Bell 1999; Carroll 1999; Crane 1999), form the second category. This type of training is important because it provides individuals and groups the chance to train in real-world situations in surroundings that do not restrict safety. In addition, participants can review their actions and discuss with other group members better ways to improve performance.

Engineers, architects, and designers employ combinations of immersive and collaborative systems extensively to solve problems that require large, complex models and data sets form the third category. Collaborative Virtual Design Environments (CVDEs) use VR to allow the viewing and review of complete systems, assembly processes, as well as individual parts (Ragusa 2001). They provide realistic 3D displays and enable rotational capability for complete 360-degree visualization as well as views from top, bottom, inside and under objects.

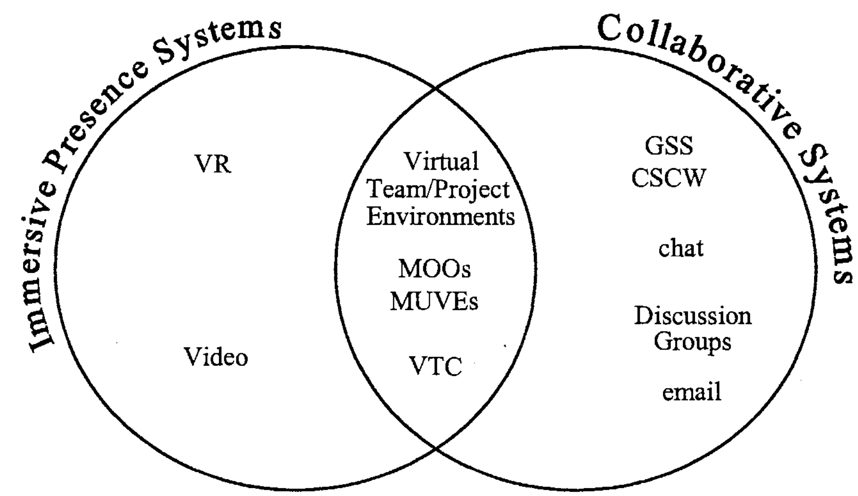

Figure 4. The intersection of immersive presence systems and collaborative systems

CSCLIP represents the intersection and integration of these three types of systems. See Figure 5. It is proposed that this integration will facilitate the achievement of psychomotor objectives in ST/DP group-situated learning environments to enable immersive presence for the next generation of eLearning such as CSCLIP. In the next section we address where CSCLIP fits within a typology of learning environments and research modes to explain differences between classroom and lab settings.

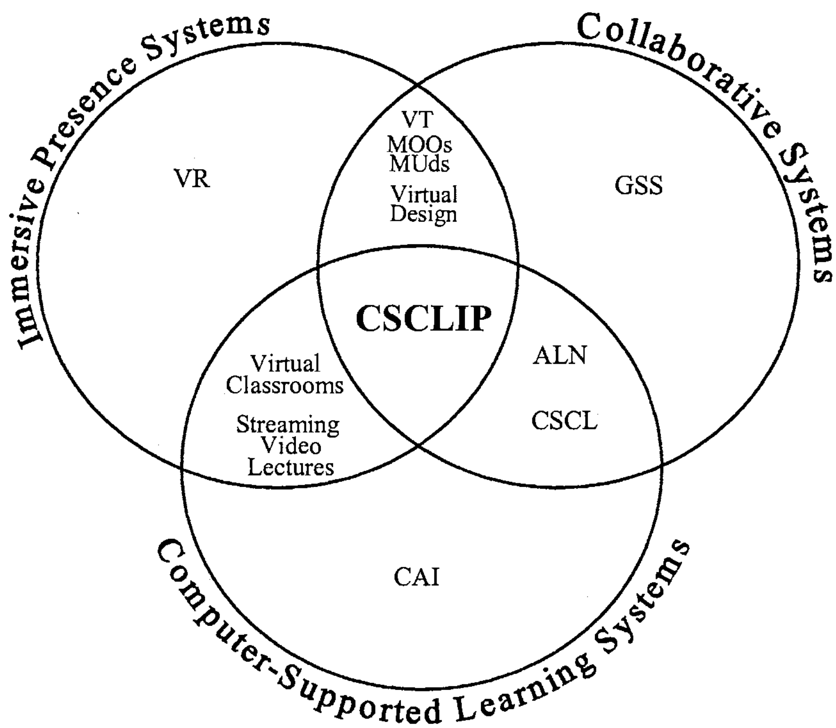

Figure 5. The intersection of all three systems

It is important to understand each system discussed above and their combinations to see what new technologies can be created and what value they can add to CSCLIP. Technology does not make learning easier, but when used effectively, it can enhance cognitive, affective, as well as psychomotor learning. CSCLIP uses these new and emerging collaborative, multimedia technologies to enable learners to get hands on lab skills efficiently and effectively. The next chapter presents a detailed discussion of the related theories used to guide CSCLIP development and implementation.

CHAPTER 3.
THEORETICAL BASIS FOR CSCLIP

The theoretical basis for CSCLIP is derived from several areas including: learning, group, technology, presence and psychomotor theories. In this section we begin with a review of the relevant theories from each domain. We then present an in depth discussion of the psychomotor skills required for CSCLIP. Finally, we discuss how the various theories come together to inform CSCLIP development.

The growth of Information Technology (IT) in general, and the Web in particular, has spawned exciting developments in Technology-Supported Learning (TSL). However, these applications and corresponding theory development have not focused on educational segments typically requiring immediate co-location of the instructor and students. Learning modules that include interactions with lab equipment typically require the students and instructor to be present in the lab (i.e., ST/SP). The purpose of the research stream is to design, develop, and assess theories that would make it possible to take a lab course without actually having to be physically in the lab.

An initial review of the literature on learning theory in general, and for technology-supported learning specifically, illustrates that there is no one theory that adequately explains how people learn, how an instructional system should be designed, how social interaction affects learning, or how people and technologies function best together (Koschmann 1994). This study examines a variety of theories that can be classified into six major categories: i) early learning theory ii) collaborative theory, iii) group theory, iv) technological theory, v) presence theory, and vi) psychomotor theory. These theories are summarized and discussed below.

3.1 Early Learning Theories

Early work by Caroll (Carroll 1990) in the study of CAI indicated that tasks should be meaningful, active, and build on the learner's experience. This is directly related to Knowle's (Knowles 1984) theory of andragogy that highlights the learner's need to know why they need to learn something. As the Internet came into prevalent use educators used it as a tool for content sharing and cognitive learning via FTP, web sites and email. Activity theory emerged as the primary theory. Activity theory does not focus on the individual learner, but on the larger activity system as a whole (Engestrom 1987). The main relationship is between the learner and the system's objective. This is not a direct relationship, but one mediated by artifacts or tools such as web based class notes. The system is in a constant state of change because learning continues to revise the learner's understanding of the system.

3.2 Collaborative Learning Theories

As technology improved, more collaborative tools were developed that supported distributed interaction. This led to educational uses that had both cognitive and affective objectives. Learning theories that included both individual and social aspects became important. Shared cognition theory is intricately related to the situated cognition theory (Lave 1988; Brown 1989; Lave 1990). Stein (Stein 1998) states that "to situate learning means to create the conditions in which participants will experience the complexity and ambiguity of learning in the real world. Situated learning often allows peers to understand how the knowledge and skills they have developed can be used in new situations."

While the socio-cognitive theory focused individual learning within a social situation, the socio-cultural approach focuses on the causal relationship between social interaction and the individual's cognitive development (Dillenbourg 1994). This theory is related to Vygotsky's (Vygotsky 1978) work in the area of Zone of Proximal Development (ZPD). Vygotsky defined ZPD as an area of learning activities that individuals can complete with the help of more capable peers, teachers, or artifacts. According to Vygotsky (Vygotsky 1978), interaction and scaffolding can aid in individual cognitive growth. Essentially, problem-solving skills can be improved under guidance or in collaboration with more capable peers, which can then be applied when the learner tries a similar problem independently.

The basic thesis of socio-constructivist theory is that knowledge is not a fixed object, but rather constructed by an individual by working and practicing with that object (Sherman 1995). The theory supports learning through authentic, challenging, and collaborative projects (Doise 1984). This theory is an extension of Piaget's (Piaget 1932) work that focused on individual cognitive development. With this theory, the objective is to create collaborative learning environments that are closely related to real world experiences. When students work together in an authentic activity, their own framework and perspectives are brought into the activity. They are able to see a problem from other students' perspectives and negotiate and create new meanings and explanations through shared understanding. Since these theories are collaborative and social in nature, important related group theories are discussed in the next section.

3.3 Group Theories

According to group composition theory, a number of factors effect the productivity of collaborating groups. These factors include age, cognitive levels of participants, group size, and demographic differences. With respect the group size, small groups seem to function better than large groups. In large groups negative behaviors such as "social loafing" can occur and some members can be excluded from interesting activities (Salomon 1989; Mulryan 1992). The dominant theory is the similarity-attraction theory (Pfeffer 1982), which indicates that more homogeneous groups have less conflict, fewer differences in opinions, faster communication, and more frequent interactions. Heterogeneous groups on the other hand generate more varied opinions, and more creative group decisions. Results indicate that there is some "optimal heterogeneity" where there are some differing opinions that trigger interaction but within group norms i.e., socially shared standards of appropriate behavior (McLeod 1996; Chatman 2001).

The overall goal of adaptive structuration theory is to present a basis for the explanation of why and how computer systems impact group behavior (Poole 1990). There are four basic dimensions: i) control – is the group led by the technology or does it try to alter the system for its own purposes, ii) attitude – this involves level of comfort with the system and the degree of respect the group develops for the technology, iii) faithful or ironic usage of the technology – is the system being used in the "spirit of the technology" i.e., its intended purpose, and iv) level of consensus – the collective beliefs and the social structure of the group needed for purposeful action.

Zigurs and Kozar (Zigurs 1994) provide integrated research framework using input-process-output (IPO) model. Input variables include task performed by the group, group composition, and the technological environment. The process variables include interaction and intermediate role outcomes. Outcome variables consist of effectiveness and efficiency, satisfaction, and cohesiveness. As the systems we are studying and developing involve extensive use of technology, it is necessary to look at those theories as well.

3.4 Technological Theory

In their media richness theory Daft and Lengel (Daft 1986) propose that a rich medium facilitates rapid clarification of ambiguous issues, while a media lower in richness is characterized by requiring a longer time to improve understanding. Face-to-face (F2F) is considered the richest form of media because in can provide immediate feedback, multiple cues such as voice inflection and body gestures, and a range of meanings can be expressed using natural language which can convey personal feelings and emotions. Media of lower richness tends to be more impersonal and include written memos or formal reports. The basic premise of this theory is that users have a mix of information requirements and communication can have varying degrees of uncertainty and equivocality that require a range of richness.

Davis (Davis 1989) theorized in the technology acceptance model (TAM) that the two main criteria used to predict a user's attitudes towards use of an IT system are perceived usefulness and perceived ease of use. Perceived usefulness is defined as the extent to which individual believe a system 'will help them perform their job better'. Perceived ease of use, in contrast is defined as "the degree to which a person believes that using a particular system would be free of effort". TAM also posits that perceived usefulness is impacted by perceived ease of use because the easier the systems is to use, the more useful it can be in improving job performance. Technology has been moving toward lower cost, personal computer, immersive presence-related technology. While theories relating to these issues are in short supply and are largely untested, in the next section we look at some of the new attempts to explain this phenomenon.

3.5 Presence Theory

Presence theory is based on earlier work in the area of social presence. Short, Williams and Christie (Short 1976) dealt with the concept from the perspective of social psychology. They defined social presence as a quality of the communications medium itself. Their work emphasized the need for social presence in understanding person-to-person telecommunications. Recent work by Biocca et al. (Biocca 2002) argues that the assessment of satisfaction and with productive performance in teleconferencing and collaborative virtual environments is based largely on the quality of the social presence. Unlike the physical environment, social communication in virtual environments might be built upon minimal or constrained social cues. Further, a theory of social presence can provide insights into the nature of nonverbal and interpersonal communication and how this affects productivity, and how the transfer of skills learned in a distributed environment can be transferred to a real world setting.

3.6 Psychomotor Theory

While the focus of this work is in the area of psychomotor learning objectives, cognitive and affective processes also interact, in order that the psychomotor skill may be integrated, meaningful, and successful (Singer 1975). It is important to recognize that the presence of all three of these factors is necessary to almost any skilled performance. They are discussed below.

3.6.1 Learning Objectives

Bloom's (Bloom 1956) behavioral learning objectives span the domains of cognitive, affective and psychomotor. Researchers have developed hierarchical taxonomies for each area: Bloom's Taxonomy of Cognitive Behaviors (Bloom 1956); Krathwohl's Taxonomy of Affective Behaviors (Krathwol 1964); and Simpson's Taxonomy of Psychomotor Behaviors (Simpson 1966). The cognitive domain focuses on intellectual learning and problem solving. Cognitive levels of learning include: knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom 1956). The affective domain focuses on a person's emotions and value system. Affective levels include receiving, responding, valuing, organizing, and characterizing by a value (Krathwol 1964). Affective levels are associated with emotional learning, feelings, being, relationships, and our ability to deal with situations. The psychomotor domain refers to movement characteristics and capabilities including physical types of learning (Simpson 1966).

3.6.2 Psychomotor Taxonomy

Much of the previous research in DL technologies and Human Computer Interface (HCI) principles related to DL has focused on achieving cognitive and affective learning objectives. Now it is time to move into the psychomotor dimension. Psychomotor objectives that can be achieved in a lab setting include basic fundamental movements such as gripping, and grasping equipment (Harrow 1972).

Although not part of the original work by Bloom, others went on to complete the definition of psychomotor taxonomies. For example, Harrow (Harrow 1972) developed a taxonomy for the psychomotor domain that is organized according to the degree of coordination including involuntary responses as well as learned capabilities. Simple reflexes begin at the lowest level of the taxonomy, while complex neuromuscular coordination makes up the highest levels (Seels 1990). Figure 6 illustrates this hierarchy.

Figure 6. From Seels and Glasgow hierarchy of psychomotor activities (Seels 1990)

Reflex movements are not part of the learning process and are considered to be an essential base for movement behavior. Examples include flexion, extension, stretch, and postural adjustments. Fundamental movements are applicable mostly to young children and include crawling, running, jumping, reaching, and changing direction. Perceptual abilities require the learner to make adjustments to his/her environment based on interpretation of information from various sources. Examples include the ability to catch, write, balance, distinguish, and manipulate. Physical activities require endurance, strength, vigor, and include activities that require strenuous effort for long periods of time. Skilled movements are the result of the acquisition of a degree of efficiency when performing a complex task. Examples include swimming, diving, and dancing. Non-discursive communication includes body postures, gestures, and facial expressions.

Singer (Singer 1975) provides an example that involves the interaction of all three learning domains. A high skill level in the game of tennis indicates effective integrated movements (psychomotor), the use of strategies, tactics, and knowledge of rules (cognitive), and appropriate attitudes, competitive feelings, and motivation (affective).

In addition to the basic psychomotor objectives of handling, manipulating, gripping, and grasping equipment that can be achieved in a lab setting, higher order perceptual objectives that require the learner to make adjustments to his/her environment based on interpretation of information from various sources will also need to be achieved. Outcomes from the perceptual category include the ability to follow verbal instructions, visual discrimination, and tactile discrimination through touch. Finally students will need to interpret non-discursive communication such as body postures, gestures, and facial expressions (Harrow 1972).

3.6.3 Psychomotor Skills Needed for CSCLIP

The psychomotor learning domain is very broad and ranges from child development skills, to performing sports, to threading a needle. In this section psychomotor skills are first discussed in terms of a broad categorization and then the focus is narrowed to specific skills needed in the CSCLIP environment. Types of transfer and principles for transferring these skills to other situations are also discussed.

Oxendine (Oxendine 1968) categorizes motor skills in three general ways: i) skills that are developed early in life such as crawling, walking, and learning to speak, ii) skills that are need to achieve educational objectives such as handwriting, and reading skills, and iii) skills that are developed for directly related benefits such as vocational or recreational skills.

The vocational skill category to be used in CSCLIP can be defined on three other dimensions, all of which run along a continuum: i) fine/gross, ii) discrete/continuous, and iii) open/closed (Singer 1975; Schmidt 1988).

3.6.3.1 Fine/Gross

Fine motor skills involve the coordination needed for precision-oriented tasks, such as typing, and inserting cabling into specific ports (Singer 1975; Schmidt 1988). See Figure 7. They are very complex and distinguished from other tasks because of the high degree of eye-hand precision required in their execution and they are usually done sitting down.

Manual skills fall midway between fine and gross skills. They are typically eye-arm-hand manipulative tasks that are usually repetitive in nature. Examples are found in factory work and industrial technology areas. Equipment, apparatus, or objects are usually used in the manipulation activity.

Gross motor skills involve the large muscles of the body. Most of the body is used in the movement. Moving large pieces of equipment would be considered as gross motor skills.

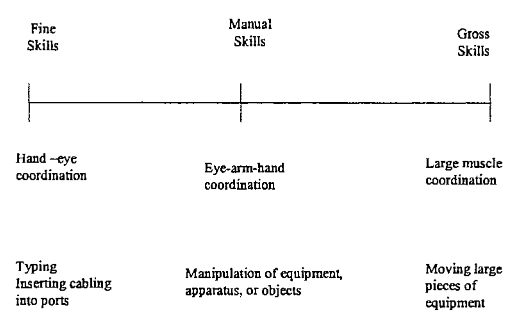

Figure 7. Fine/Gross motor skills

3.6.3.2 Discrete/Continuous

Discrete skills have a recognizable beginning and end (Schmidt 1988). See Figure 8. In their most simple form they are binary key presses. They are quick in nature and usually only require a few seconds to complete. The situation under which they are performed is stable and clearly defined. They are usually cognitive in nature. Schmidt (Schmidt 1988) provides a common example: a subject is asked to press one of four buttons when one of four lights comes on. The subject needs to decide which light goes with which button. The decision the subject needs to make is about which button to push, not how to push the button.

Serial movements fall midway, and involve a sequence of discrete actions put together in time to make some whole activity. Examples include assembling and connecting components.

Continuous movements typically have no recognizable beginning and end. The behavior continues until it is arbitrarily stopped. A continuous task usually has longer movement times than a discrete task. An example is communication with group members.

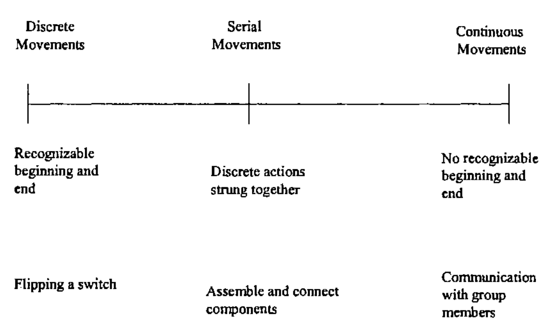

Figure 8. Discrete/Continuous movements

3.6.3.3 Open/Closed

In an open loop task, information about the performance is not generated until it is finished (Singer 1975; Schmidt 1988). See Figure 9. They are tasks done in which the environment is always changing. An example is trouble-shooting problems. The participant may have a general guideline for action, but specific actions are done on the fly. The outcome is not judged until it is complete and there is no opportunity to use feedback to adjust the performance.

In a closed loop task, the environment is completely predictable or perfectly stable. The participant can make use of knowledge about the performance to make continual adjustments. Movements can be planned in advance. Examples include writing and typing.

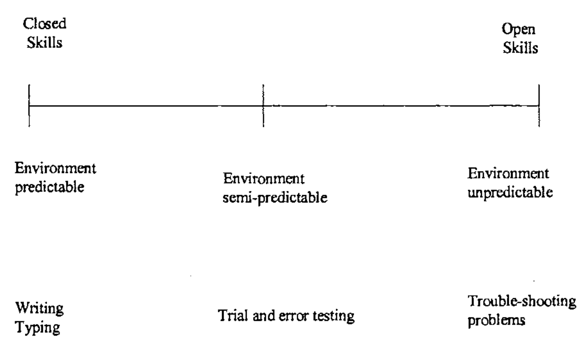

Figure 9. Open/Closed movements

Explicit learning objectives to be achieved by CSCLIP can include:

- Students will display the ability to navigate throughout the lab either physically or virtually
- Students will display the ability to recognize and choose proper equipment for task completion
- Students will display the ability to assemble and connect lab equipment

- Students will adapt, manipulate, and control lab equipment in response to emergent situations

Skills needed to accomplish the objectives of CSCLIP in a telecom domain can be categorized as fine, serial, and somewhere in between closed and open.

3.6.4 Skill Transfer

Once required skills are acquired in a lab environment, it is important that they can be used in other, real world settings. Drowatzky (Drowatzky 1981) refers to this as transfer and defines it as "the process in which a person uses learning that he or she has acquired in one situation by applying it to a new or different situation." This tendency to use past experiences in new situations was noted by Thorndike (Thorndike 1928), who calls it the spread of effects.

Transfer can be characterized as either positive or negative (Drowatzky 1981). Positive transfer takes place when the skills that the student originally learned apply equally well to the new situation. Negative transfer takes place when the skills that the student originally learned and may impede with those required for the new task and actually hinder completion of the new situation.

There are a number of factors that influence transfer both positively and negatively (Drowatzky 1981):

- Past experience in a general learning setting as well as in settings similar to the new task enhance skill transfer
- Stimuli and response similarity for the initial task enhance performance for the task to be transferred
- Exposure to a wide range of experiences is likely to lead to more positive transfer
- Knowledge of rules and relationships related to the task improve transfer when skills are taught with the intention of transferring over to other skills
- Attitude can impact transfer with those having high anxiety about the task performing poorly or having negative transfer

Measures of transfer effect are very straightforward and can be measured in terms of efficiency, accuracy, and response magnitude (Schmidt 1975). Efficiency is the speed at which the transferred task is completed. Accuracy is assessed by the number of errors committed during completion of the transferred task. Response magnitude is measured by the complexity of the transferred task completed.

3.6.5 Cybernetics Theory

Cybernetics is the theory that has provided the most information in motor-skill learning and was developed by Wiener (Wiener 1961) and further refined by George (George 1962). Cybernetics compares the human brain to the computer. Both have input and output systems, a control, and a storage system. A human receives stimuli, uses the brain as a control device, and uses memory a storage device. Cybernetic theory is based on feedback. Feedback is information in the form of errors that is sent back to the device controlling the output. The learner then modifies the input to correct the output. Adjustments are made by the detection of errors. The learner to make adjustments then uses this information; otherwise performance will not be improved. This activity continues until the goal and behavior are matched.

CSCLIP can be defined as a theory-based system involving hardware, software, and people that supports the achievement of psychomotor skills in a distributed environment. Figure 10 represents insights from theories that inform it.

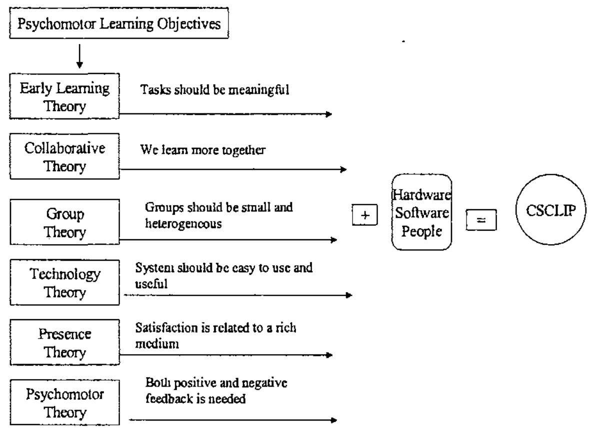

Figure 10. Theories that inform CSCLIP

3.7 Theory Applications

The application of the theories discussed in the previous sections was used to guide the design and development decisions in a CSCLIP setting. See Figure 11.

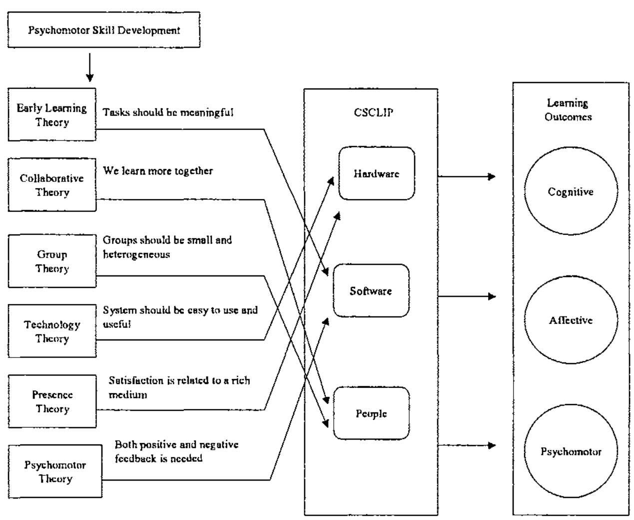

Figure 11. Application of CSCLP theory

Technology and presence theories were applied to decisions about hardware such that it is easy to use, and enables a rich medium that includes audio, video, chat, and desktop sharing. Early learning theory and psychomotor theory were employed in software development. The software design is very similar to the actual lab setting and provides both positive and negative feedback. Collaborative learning and group theories aided in decisions regarding group size, with random assignment to a group resulting in heterogeneous groups. Application of CSCLIP technology results in cognitive, affective, and psychomotor outcomes. Careful consideration based on theoretical understanding helped avoid costly, time consuming mistakes in system development. In the next section a theoretical framework for the study of CSCLIP is presented.

CHAPTER 4.

RESEARCH FRAMEWORK - EMPIRICAL DEVELOPMENT

A key issue in developing such next generation eLearning systems is to be guided by rigorous empirical testing. Development of the next generation of eLearning systems that can support lab experiences must be guided by rigorous empirical testing, in order to demonstrate the value-added for both learners and instructors. This section presents a research agenda to reach that end. Figure 12 presents a framework for the study of CSCLIP systems. Three constructs and how their relationships affect the learning outcomes are identified and discussed below.

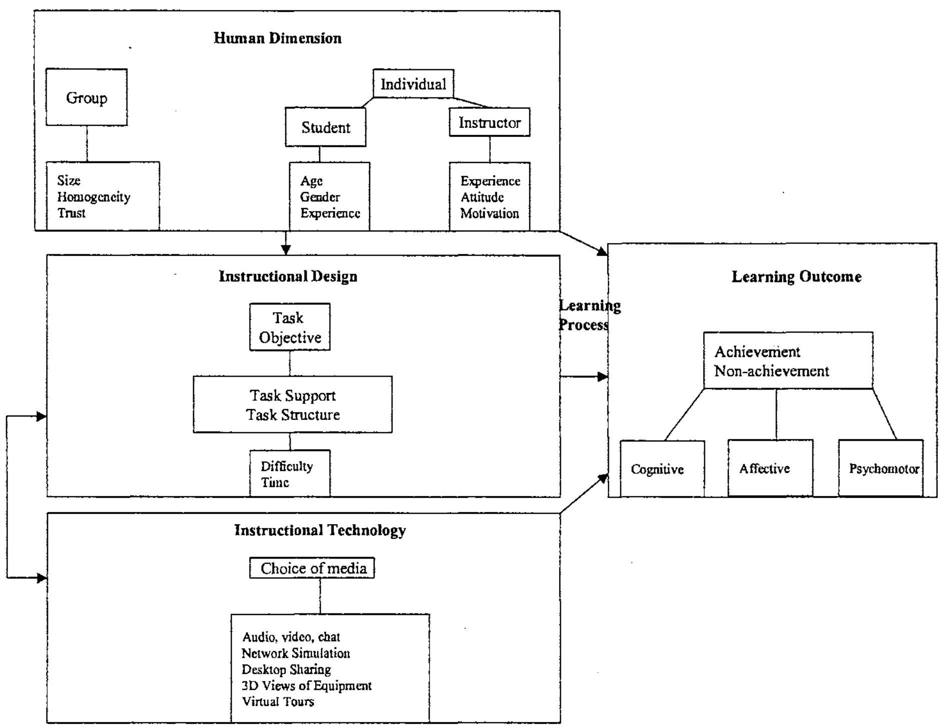

Figure 12. Framework for research in CSCLIP

4.1 Human Dimension

Within the human dimension it is important to look at both group and individual differences because both can have an impact on learning outcomes. Relevant group variables include group size and composition. Group size has been shown to be different in computer-supported environments than in F2F environments and if this also holds true when IP is required need to be explored. Group composition poses such concerns as homogeneity, distribution, and history. How and if such concerns are relevant in a CSCLIP environment and how best to control or manipulate such variables to provide for the best learning outcomes need to be investigated. In addition, it will be important to find the most effective way to promote teamwork. While the goal is to eliminate the need for travel, perhaps a more short-term goal would be to reduce travel and investigate the possibility of students visiting the campus for one lab session in order to meet team members F2F.

Individual differences can be characterized as either student or instructor. Relevant student variables include preferred learning style, cognitive ability, and computer skills. Additionally, individuals have personal and cultural characteristics, such as demographics (age, gender, etc.) language and communication skills, motivation, and attitudes, all of which can affect ones learning experience and interactions with the instructor, fellow students, and the CSCLIP environment (Russ-Eft 2001).

Relevant instructor variables include level of technical comfort, teaching style and interactivity. Researchers (Webster 1997; Hantula 1998) have found that instructors' level of technical proficiency and comfort, in terms of having the ability to control the technology and having a positive attitude toward it, affects learner ratings of instructors and positive outcomes. Also important are instructors' attitudes toward DL and their perceptions of the relative advantage of DL (Webster 1997).

It is believed that instructor involvement and participation level becomes extremely important in CSCLIP interactions. It is necessary to discern which of these variables will also be important in environments requiring IP. Instructors working in this new environment should be observed to gain insights as to which variables apply, and perhaps to discover new ones in this domain.

The human dimension is related to instructional design in that there are groups or individuals that design learning tasks and groups and individuals who are expected to perform learning tasks. A discussion of instructional design is presented next.

4.2 Instructional Design Strategy

Task objectives shape the backbone of instructional design, determine instructional content, and form the basis for evaluation. Gagne et al.(Gagne 1992) placed learning objectives into three areas: i) the learning of verbal information or knowledge, ii) the establishment or changing of attitudes, and iii) the acquisition of motor skills. These are discussed below.

The overarching goal for students in the telecom lab is that they will develop an understanding of networking technology for voice, video, and data. Students taking the lab will have been exposed to a broad theoretical background in these three areas prior to attending the lab, however it will be valuable to provide them with verbal information in order to tie the theory together with actual hands-on experience. It is important to provide this type of information to the student, as he/she may need it to continue learning within the domain. Although some of the information can be looked up easily through a variety of sources, verbal information may be required to further pursue study of the subject and make completion of the experiments more efficient. This information can be presented either orally through lectures or in printed form for illustrative purposes. We project that the CSCLIP environment will enable this type of learning because it will be available in a variety of formats and will appeal to students with a wide variety of learning styles.

Attitude involves a choice of personal action (Gagne 1992). Students will need to develop several attitudes to achieve a successful learning experience in the CSCLIP environment including: cooperation with the instructor and other students; paying attention to the instructor and other students; thoughtful communication; and responsible equipment use. The challenge is that the conditions that facilitate the learning or changing of attitudes are very complex and there are many different and contrasting views on this subject (Martin 1986). This may prove to be especially challenging in the distributed setting of CSCLIP.

Motor skills are learned capabilities with outcomes including efficiency and precision (Gagne 1992). This type of skill plays a key role in CSCLIP. Three levels of skill performance can be identified: i) skill acquisition, ii) skill competency, and iii) skill proficiency (www.reproline.jhu.edu/english/5tools/5presgrp/idchpt6/). In the skill acquisition phase students may observe skills from the instructor and attempt to repeat them, or they may perform a skill based on guidance from other students or the instructor. Skill competency occurs when the student can perform the required steps in the proper sequence although they may have difficulty proceeding from step to step in an efficient manor. Skill proficiency involves efficiently and precisely combining more than one skill activity in the proper sequence. Possible psychomotor objectives could include:

- Recognize and identify types of equipment
- Place, position, or arrange equipment within the lab
- Turn knobs and throw switches to make specific outcomes occur
- Monitor and correct problems

Once specific objectives are identified, instructional design processes are used to develop task structure. The task structure is dependent on the task objectives. If for example, the task objective is relatively easy, e.g. taking a virtual tour to become familiar with the lab, less structure is required. Providing general instructions as to how to use the navigation tool is sufficient. As the task becomes more difficult, more structure is needed. In early pilot testing it was found that in order to stay on task it was very important to ensure high task structure so that both local and remote groups had a complete understanding of what the other group was doing. Variables that relate to task include difficulty, time to complete, importance, and enjoyability.

Instructional design is related to instructional technology in that the designer needs to identify existing technologies that can be used. A two-way arrow is shown in Figure 12 because the designer also needs to identify technologies that need to be developed in order to implement the design. A discussion of instructional technology follows.

4.3 Instructional Technology

Technology will play a key role in implementing CSCLIP. Based on theoretical underpinnings, the quality, reliability, ease of use, usefulness, and accessibility of the technology are important concerns. Students in the CSCLIP environment will be provided with a number of technologies including:

- Audio, video, and chat
- Networking simulation software
- Desktop sharing
- 3D views of lab equipment
- Virtual lab tours

Some tasks require a richer medium, using voice, video, and chat. Other tasks could be achieved using primarily audio and desktop sharing, with little need for video or a highly realistic simulation.

The technology listed above make up the immersive presence component of CSCLIP described in section 2.3. Immersion refers to a quantifiable measurement of the technology e.g. screen size, resolution, and bits per second (Slater). It is a function of the VR system, with immersion being achieved in varying degrees. A necessary condition is the engagement of at least on sensory perception (usually visual) (Slater 1994). Engaging additional senses e.g. audio, and richer, more realistic representations of the environment can increase the degree of immersion.

Immersion can then lead to presence (Slater 1994). Presence is a psychological property that refers to the remote students' sense of actually being in the physical lab. This property varies with each individual and can be measured using a self-report instrument. To summarize, immersion measures the type and amount of technology while presence measures the students' state of consciousness in the CSCLIP environment.

4.4 Learning Process

Once the students, instructor, tasks and technology converge, a learning process takes place. The learning process can be positive or negative and can be affected by the level of effort put forth by group members, the level of trust among group members, as well as the degree of mutual respect they hold for one another. The process category of variables is influenced by the sequential nature of the steps, and the necessity for scaffolding. In a technology-based educational setting, scaffolding, in the form of coaching or modeling, supports students as they develop new skills or learn new concepts (Winnips 2001). When the student achieves competence, the instructor or student removes support. The student continues to develop the skills or knowledge on his or her own. The process variables are also influenced by the instructor's ability to determine level of completion, and the nature of the communication between group members. Group issues include size, location, and homogeneity can effect outcomes as well as individual differences including learning style, age, gender, experience, and motivation. When the learning process is completed outcomes need to be assessed. They are discussed next.

4.5 Outcomes

All the variables identified influence the quality and quantity of outcomes. Learning outcomes can be broadly characterized as achievement or non-achievement. Achievement outcomes include quality of task completion, correctness, and improved cognitive understanding. Non-achievement outcomes include information overload, increased participation, and affective reward. The ultimate research goal is to explore the relationships among the different variables and determine how their interaction can improve the outcomes for both lab-present and distributed learners working in a CSCLIP environment. One challenge is to reliably and validly measure outcomes; therefore, we anticipate the need to develop new metrics to assess the performance of lab groups with both lab-located and distributed members.

4.6 CSCLIP Theory

Having identified the important constructs and their relationships and operationalized them into measurable variables, Figure 13 provides a more granular view of the CSCLIP theory.

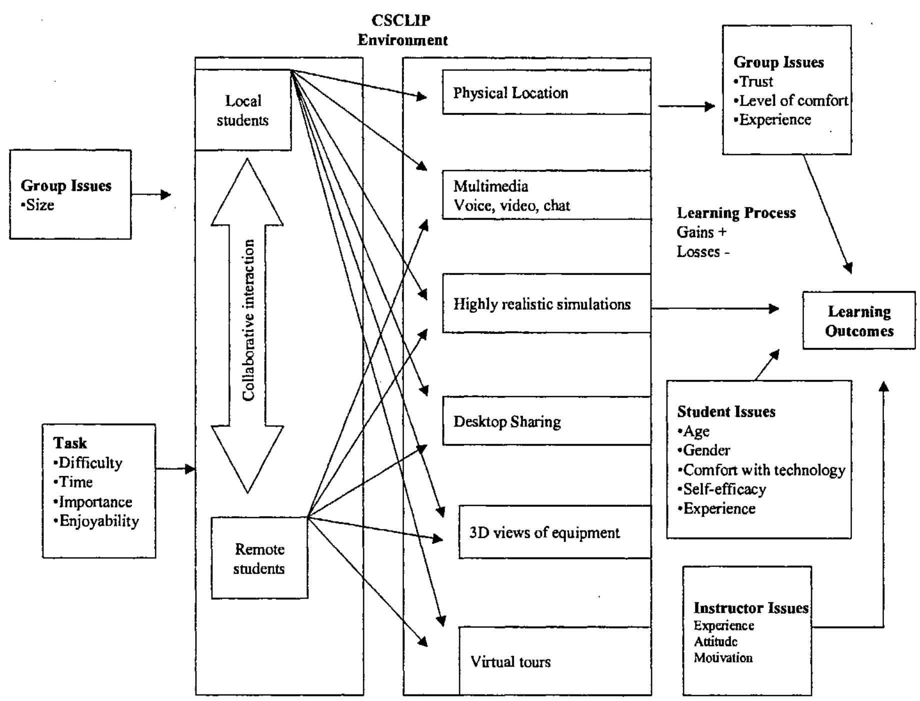

Figure 13. CSCLIP Theory

The selected task will have an impact on the technology used. As indicated previously, some tasks require audio, video, and chat, while other rely primarily on audio and desktop sharing. Within the CSCLIP environment some students and the instructor will always be in the physical lab with local students who have access to all the same technologies as the remote students.

Group variables can be further characterized as those that impact technology use and those that are affected by the technology. For example, with a large group of students, the instructor might need to wear a head mounted camera so that many students can view equipment or the blackboard from his/her perspective. With a smaller group, the instructor might be able to communicate effectively using only chat technology. Group variables that might be effected by the technology include trust, level of comfort, and experience of the group. Individual variables impacted by the technology include age, gender, level of comfort with technology, self-efficacy, and experience. All of these variables collectively influence both achievement and non-achievement outcomes.

4.7 The Role of CSCLIP in Enhancing the Transfer of Psychomotor Skills

CSCLIP provides support for the activities mentioned above by four mechanisms: process support, process structure, task structure, and task support (Nunamaker 1993). Process support for CSCLIP is provided through the use of audio, video and chat using basic Transmission Control Protocol/Internet Protocol (TCP/IP) networking technology. Process Structure is provided through the lab exercises themselves and written scripts that serve as scaffolding. In addition the software and hardware provide feedback that help to guide the students through the process. Task support refers to the instructional infrastructure (e.g., the virtual tours of both the physical layout of the lab as well as 3D visualization of all equipment being used). Task structure refers to the instructional lab modules that provide information for task completion. These mechanisms have been shown to increase the effectiveness, efficiency, and satisfaction of distributed groups by increasing process gains and reducing process losses (Nunamaker 1993; Nunamaker 1996-97). Process gains are activities that improve group performance over individual performance. Examples of group process gains include more alternative solutions being generated, improved error detection, and increased synergy, leading to better overall performance (Nunamaker 1991). Process losses diminish group performance compared to individual performance. Examples of group process losses include fragmentation or turn taking when speaking is necessary, domination by one or a few individuals, fear of negative evaluation by other group members, and information overload. Process gains are increased through improved communication channels, thus reducing fragmentation, dominance, and social loafing and enabling members to stay focused on the task. Based on the literature and bodies of research cited previously, the following proposition has been formulated:

CSCLIP enables the transfer of psychomotor skills defined in terms of efficiency, satisfaction, and cognitive development.

This proposition can be further explained in terms of the theoretical underpinnings in the areas of collaborative learning, group interaction, technology, social presence, and psychomotor skill transfer. Figure 14 shows the specific theories from each learning domain, the resulting hypotheses, and their operationalized variables.

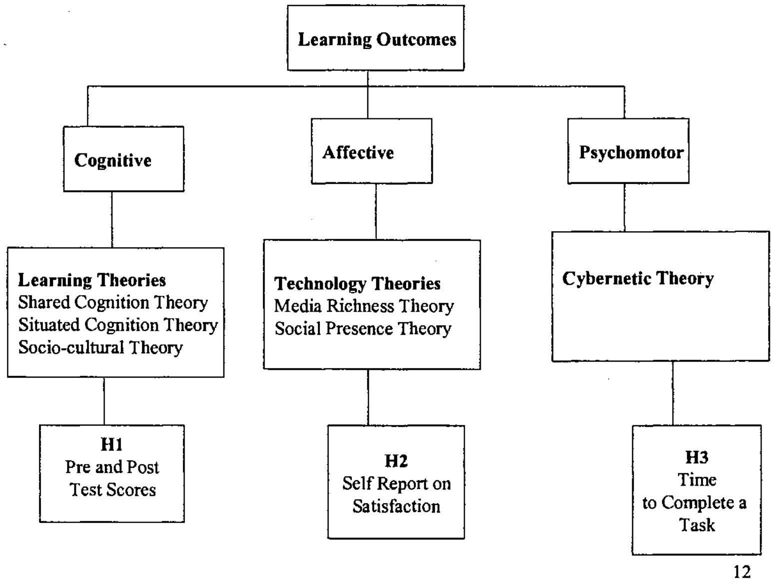

Figure 14. CSCLIP Hypotheses development

While much empirical testing has been done with learning theories, CSCLIP provides an opportunity to test these concepts in a new domain. Subjects to be tested in the CSCLIP environment will be either F2F, local or remote. The local and remote students work together in a group but in some cases there might be differences between F2F, local and remote subjects.

Based on socio constructivism, students learn best in a realistic, collaborative setting. We assert that the CSCLIP environment provides the support for increased process gains and reduced process losses. We hypothesize:

H1: Subjects undergoing laboratory experiences in F2F or CSCLIP (local and remote) groups will have no difference in cognitive understanding of the topic.

Relying on the technological theory of Daft and Lengel (Daft 1986) and Davis (Davis 1989), and the related social presence theory of Short et al. (Short 1976) we posit that the highly immersive, easy to use CSCLIP setting will enable communication that will result in user satisfaction. We hypothesize:

H2: Subjects undergoing laboratory experiences in F2F or CSCLIP (local and remote) groups will have different levels of satisfaction with the motor learning process.

Basing our assumptions about psychomotor skill development on cybernetics as developed by Weiner (Wiener 1961) and George (George 1962), software for CSCLIP was developed that provides both positive and negative feedback throughout the learning process. Also, applying the similarity-attraction theory of Pfeffer (Peffers 1999) to CSCLIP, small, heterogeneous groups will have improved error detection resulting in improved productivity. We hypothesize:

H3: Subjects undergoing laboratory experiences in F2F or CSCLIP (local and remote) groups will exhibit no difference in time of completion of similar future motor tasks.

CHAPTER 5.
A VIRTUAL TELECOM LAB UNDER DEVELOPMENT

A CSCLIP-based system is currently under development at OSU. Although most required coursework can be delivered through a combination of Web and video technologies, the Master of Science in Telecommunications Management (MSTM) program still requires all students to travel to the university to receive significant hands-on learning in the use of technical equipment. This lab course covers aspects of voice, video, and data networking (Scheets 2002). The goal is not to train students to be experts on specific hardware, but to ground learning obtained from theory-based lecture courses, familiarize them with some of the telecommunications equipment they may become involved with in the future, and enlighten them about some of the processes that technicians deal with on a daily basis. Although feedback on the lab experience is almost entirely favorable, compelling travel to a common site is often viewed as undesirable. Continued advances in wide area and last mile communications, along with other integrated technologies, show promise for making a virtual lab experience as effective as a co-located interaction and leveraging these developed support mechanisms may improve the experience of even those who do attend the lab in person.

In order to orient remote students to the physical structure of the lab and the equipment available in that lab, a simulated three-dimensional virtual environment has been constructed, through which all students can tour the lab prior to the first day of class. It is possible to "walk" the halls and investigate a variety of equipment, without regard to student location, physical accessibility of the room, and equipment availability. In some ways, this virtual tour is better than a physical tour, because equipment from the lab can be linked to detailed technical information from manufacturers and protocol developers. For example, someone could walk around the telephone switch, select and remove a critical component for closer inspection, and pull up technical details for that device, without disrupting the function of the physical switch.

Additionally, there are several live cameras in the lab, any of which can be remotely accessed by students via a point-and-click virtual map of lab. Almost all areas of the lab can be viewed by selecting a part of the lab to "be in" through the various camera nodes. To prevent eavesdropping and spying, whenever someone connects to a camera, his or her image is displayed on a co-located monitor. The video link also includes an audio connection to the local monitor, allowing a remote student to verbally interact with students in the immediate area of any pre-positioned video node.

The integration of the virtual tour with a network of conferencing nodes will allow participants to move around the lab in the virtual world, manipulate components of live equipment without disrupting operations, and engage in communication with students physically present in the lab or at another remote location. The expectation is that the virtual environment will enhance the experience by creating an "off-line" environment that can be used for between-class learning, as well as a route to move from one synchronous environment to the next. Figure 15 shows the navigational map of the lab, the camera controls, and a virtual cable bin.

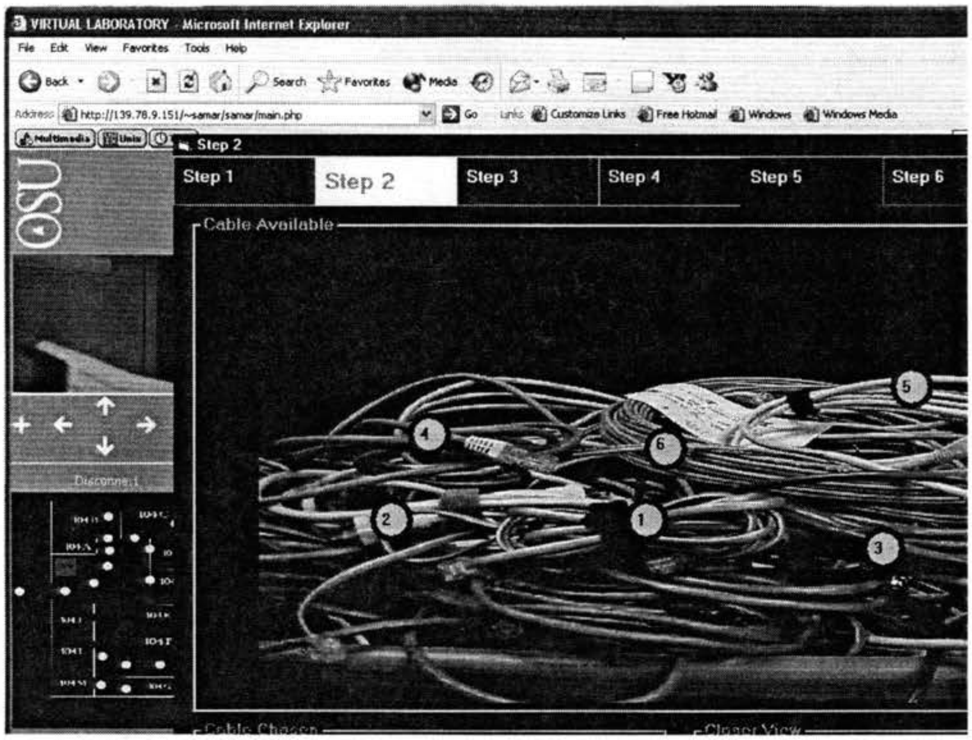

Figure 15. A virtual cable bin

One of the main psychomotor objectives of this lab is the manipulation and connection of lab hardware. Either physical-layer connections of cabling or facilities to access alternate media (wireless, etc.) are required early in the implementation of any voice, video, or data network. During that physical process, cabling problems are often experienced, identified, and resolved. This experience grounds classroom learning in electronics and signaling, and data link-layer communication, by exposing students to randomly occurring problems similar to those that may be experienced in a production network.

Because remote students cannot physically manipulate cabling, an alternate means of exposing them to a similar experience, and more importantly, the same logical processes toward a solution, is necessary for the remote exercise to have similar pedagogical value to the local experience.

This is accomplished with physically connected links over which logical connections are made. For instance, if a connection to a hub would normally be made with a category 5 twisted pair cable with RJ-45 connectors, that cable will be installed and tested in the physical lab. A remote student would select the appropriate cable from a "bin" of virtual cables available through the interface as shown in Figure 15.

If the cable ends are physically correct, the software will allow the student to graphically connect to the hub. See Figure 16. If the correct media (between the terminations) are selected, there is a high probability that a Simple Network Monitoring Protocol (SNMP) message will be sent to the hub activating the existing physical connection already in place. This virtual cable connection is then made available to all students just as if a physical connection had been established. Virtual cabling errors will be generated at random, however, to simulate difficulties that are experienced in the co-located lab setting and in production networks. Students will then need to trouble-shoot with virtual versions of cable testing equipment, and possibly even "make" a new cable from its components. Success is, once again, based on probabilities, just as it would be in the physical world – bad cables are mixed with the good cables in the cable bin.

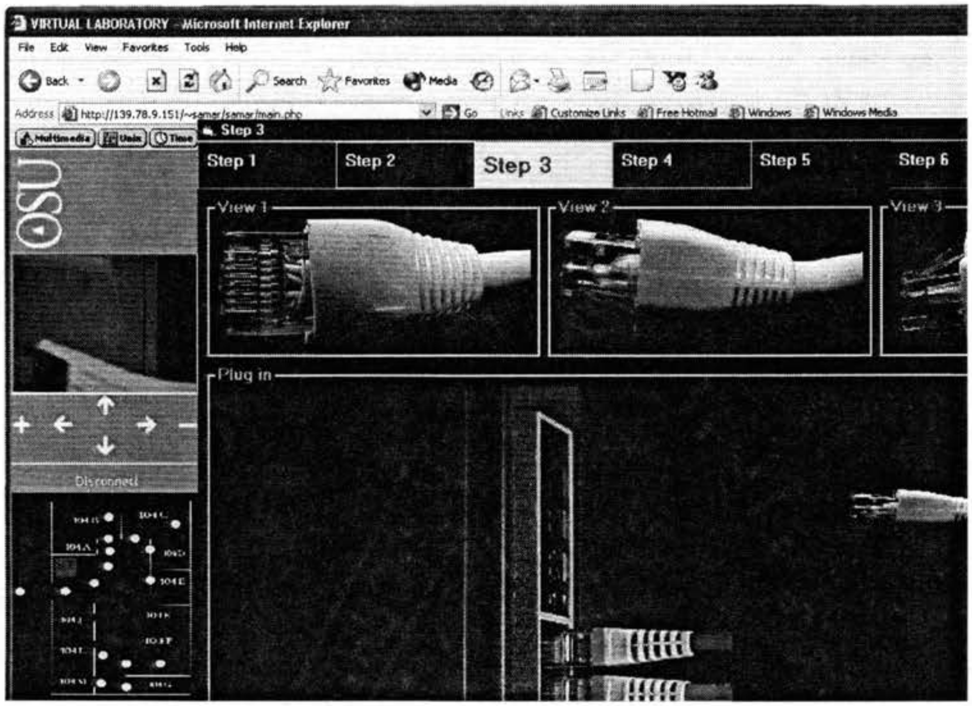

Figure 16. Virtual cable connection in process

Simulation of cable connections, the variety of possible media problems, and even cable testing are the means by which we are able to capture the important aspects of the fully physical activities for the distributed student. Because we base failures on probabilities, remote students will be no more likely to experience problems than would those physically making connections in the lab. If they do run into a simulated failure, remote students will then have the capability to trouble-shoot the problem and resolve the issue with a series of related simulations. Only by successfully navigating the simulated repairs will the link be activated and logically available to either the remote or local students.

These are just a few examples of virtual applications from those that have been developed and tested, but many others are also available to help the group of local and remote students to work together to achieve psychomotor learning objectives of a telecommunications lab course.

CHAPTER 6.
RESEARCH METHOD

6.1 Experimental Design

A basic pre-test - treatment - control - postmeasure research design was implemented. Subjects participated in the CSCLIP lab-learning environment and then were tested on their cognitive, affective, and psychomotor outcomes.

6.2 The Course

The course is a senior level course in data communications. It is required of all Management Science and Information Systems (MSIS) students. The students are presented with management-oriented information about data communication. The basic components of data, voice, and video communications are discussed so that the student will become familiar with many of the concepts and acronyms used in the telecommunications industry. The course also provides students with some basic theoretical background in the areas of voice, video, and data and how they are transmitted over the telephone system, Local Area Networks (LANs), and Wide Area Networks (WANs).

6.3 Subjects

A total of 78 undergraduate students participated in the experiment. Due to missing data, the number of subjects available for statistical analysis ranges from 58 to 72. For the testing of Hypothesis 1 there were 16 F2F subjects, 23 local subjects, and 19 remote subjects. For the testing of Hypothesis 2 there were 20 F2F subjects, 26 local subjects, and 26 remote subjects. For the testing of Hypothesis 3 there were 19 F2F subjects, 27 local subjects, and 24 remote subjects. Causes of missing data include students missing the class when the post-test quiz was given, and failure to complete portions of the survey. Lab participation is a required part of the course and students received 50 points if both lab sessions were completed.

The subjects were representative of those in a technical major in that 75% were male and the average age was 23.5. The largest ethnic group was Caucasian at 57.3%, with the second largest group being Asian at 30.7%. The majority, 88%, were seniors, with 45% of participants indicating they had frequently used computers.

6.4 Independent Variable Manipulation

In order to test the hypotheses, three different treatments were administered. The control group consisted of students that were all co-located in the same physical space. This is the traditional F2F setting that has been used previously in the lab. Their task was to work together to physically connect a LAN. Treatment groups were either "local" or "remote". Local students made physical connections and configurations to connect a LAN while remote students watched via videoconferencing. The remote students then used the previously discussed cabling simulation software to "virtually" connect their portion of the LAN. Local students watched the remote students using desktop sharing software. Both control and treatment groups had the same size of four, with the treatment groups having two subjects as local members and two subjects as remote. A more detailed description of the lab task is provided in section 6.5.

6.5 Procedure

The basic goal was to study the transfer of psychomotor skills learned in a remote telecom lab and compare them to those learned in a F2F setting. The overall objectives were: i) become familiar with some of the capabilities of an Ethernet peer-to-peer LAN, ii) become familiar with some of the duties of a peer-to-peer LAN Network

Administrator, and iii) develop basic LAN trouble-shooting skills. Figure 17 shows the experimental procedure that was used.

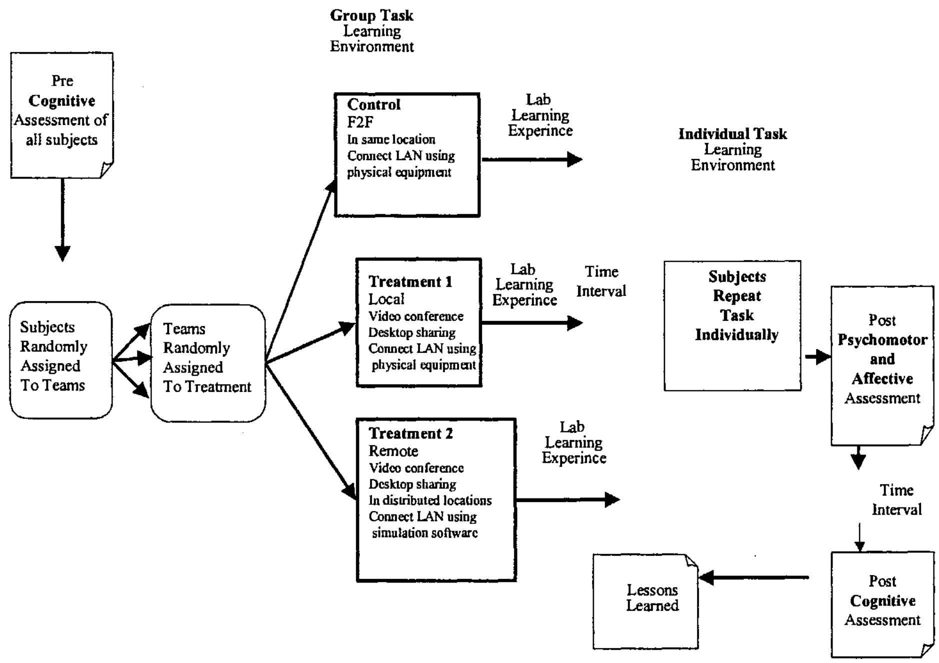

Figure 17. Experimental procedure

Prior to coming to the lab, subjects were given a pre-lab quiz based on in-class theoretical presentations. This was done to make certain that all subjects had a baseline understanding of the background information needed to perform the task. It was recommended that they visit the virtual lab web site to take a virtual tour and to familiarize themselves with 3D views of the equipment used for LAN connectivity. Subjects were asked to sign up for various time slots. During the first week, lab sessions were held Monday, Tuesday, and Wednesday from 9am to 5pm and subjects were allotted 90 minutes to complete the task.

As the subjects arrived in the lab they were randomly assigned to groups, and then the groups were randomly assigned to a treatment i.e., a F2F, local, or remote group.

Local refers to subjects or equipment located in the telecommunications lab. Remote refers to subjects or equipment located at the remote subjects' place of interaction. All students received a brief description of the task and a handout with instructions for task completion. All groups used the same equipment: Dell Computers, Extreme Switches, Cat 5 cabling, camera, microphones, and all necessary software was previously installed. Students were unaware software was running that captured key strokes and screen shots in both group and individual settings, however after the experiment they were debriefed and it was explained that such data was captured for later detailed analysis.

The F2F groups worked together in the same room and communicated normally. Remote students were first instructed to contact their local team members by connecting to the local camera using NetMeeting and use ipconfig to exchange IP addresses. Subjects could view their teammates as well as themselves using the picture-in-picture feature. See Figure 18.

Figure 18. Making initial connections

Local subjects connected their LAN while the remote subjects observed through the camera connection at the local location. Subjects then launched Tight VNC, to enable the desktop sharing feature. See Figure 19.

Figure 19. Launching desktop sharing

Remote subjects then used the virtual cabling software previously shown in Figures 15 and 16 while the local students observed using desktop sharing.

The next task was to properly set up the Windows operating systems so that all computers could communicate and "see" each other. The local subjects did this in the normal way, while the remote subjects accessed their "local" PC using desktop sharing. To accomplish this they needed to give the computer a name, a workgroup and an IP address. See Figure 20.

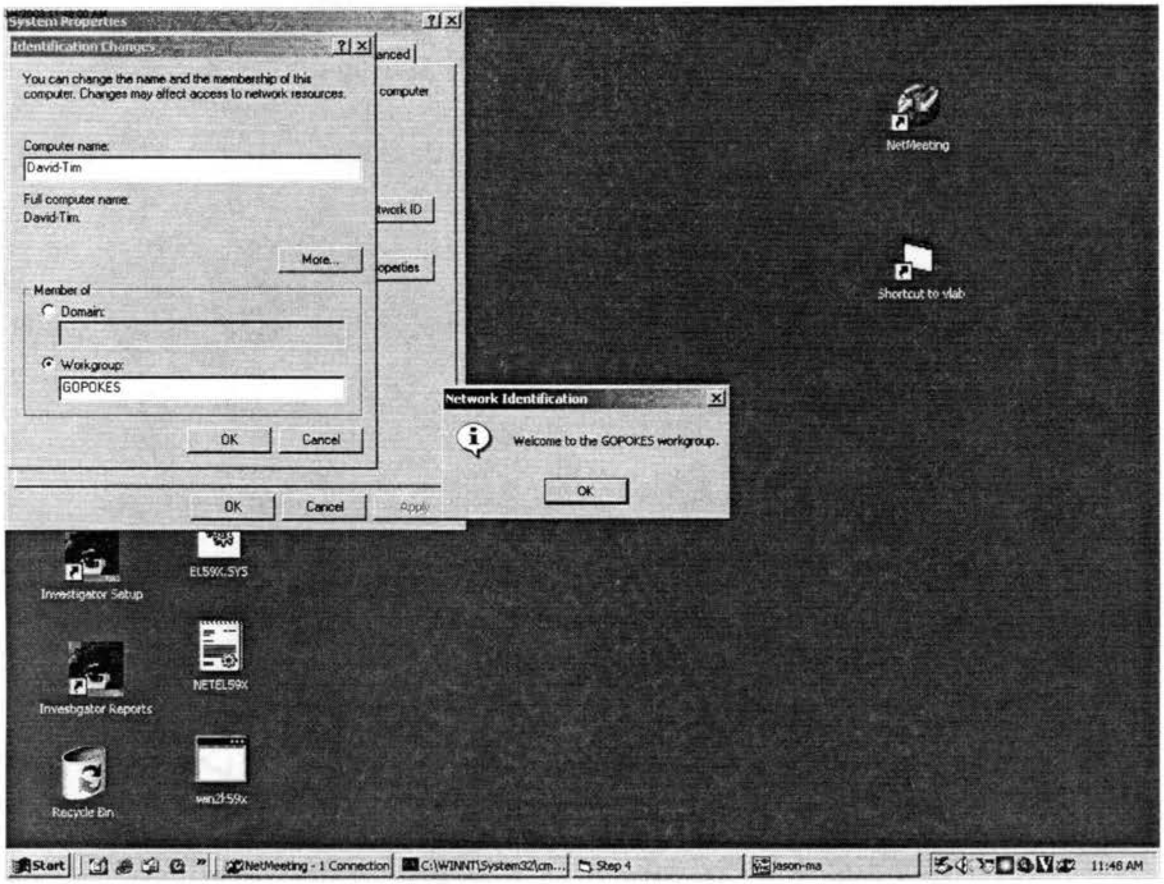

Figure 20. Windows configuration

Subjects were then instructed to test for connectivity using Packet Internet Groper (PING), and then using Windows "Computers Near Me" to see the computers on the network that were properly connected. See Figure 21.

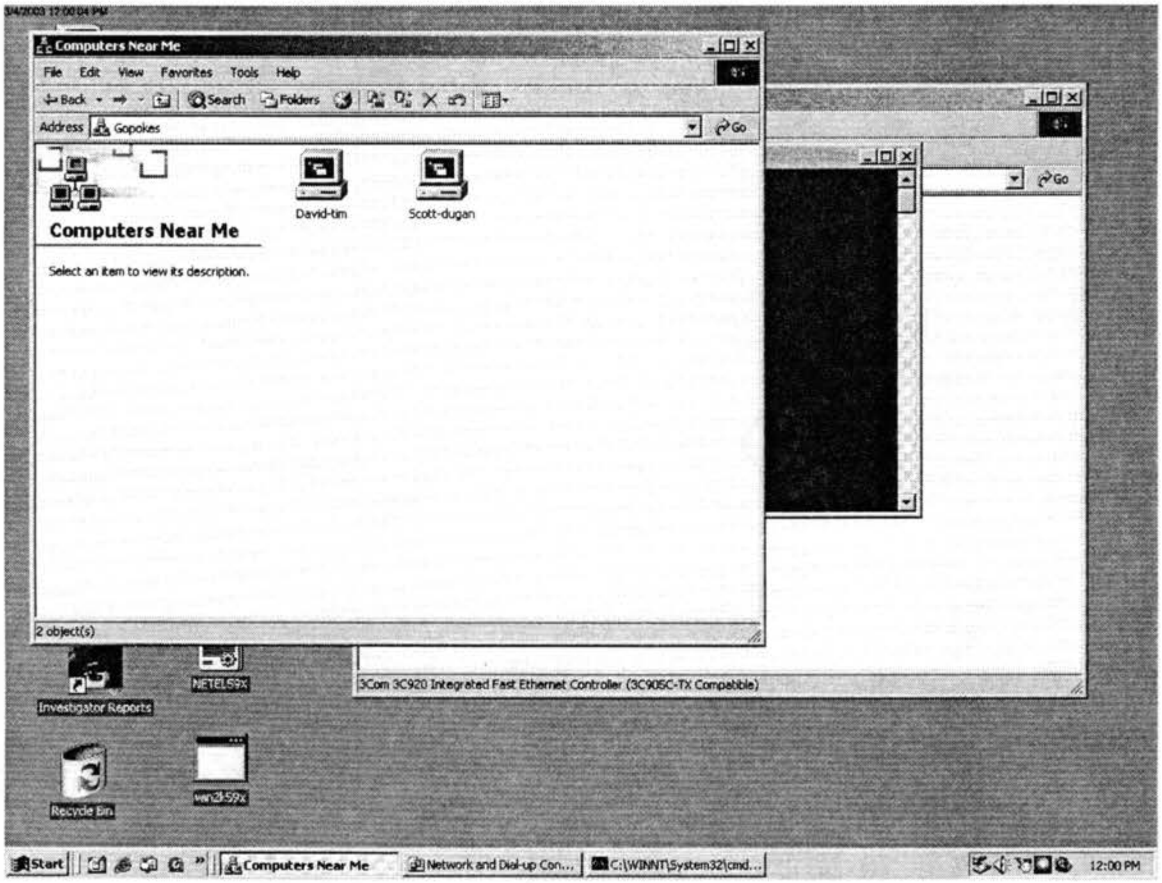

Figure 21. Computers connected to the LAN

Individuals returned one week later in a slightly modified setting and were asked to set up a LAN individually. Each student performed the follow-on task in a different environment to ensure that they could generalize from the environment they learned in to another environment. The time frame followed the same Monday, Tuesday, and Wednesday time slots and subjects were given 90 minutes to complete the task. Upon completion of the task, subjects were asked to complete a survey about their overall satisfaction. Later the subjects took a post lab quiz to assess improved understanding. All participants were debriefed.

6.6 Dependent Variable Measurement

Change in cognitive understanding was measured by comparing pre-test quiz scores to post-test quiz scores. Satisfaction was self-reported by the subjects. The satisfaction measure used was adopted from Michie et al. (Michie 2000). An example from the scale was: "I am satisfied with my performance in the lab." The instrument was scored using a 5-point Likkert scale with 1 indicating strong disagreement and 5 indicating strong agreement. The scale's alpha was 0.9. Psychomotor skills were measured in terms of efficiency and response magnitude (i.e., the number of computers that were connected.) Efficiency was measured in terms of the time to complete the task and the response magnitude was measured as the number of PCs successfully connected to the LAN. This data was extracted from the keystroke capture software in a spreadsheet format. The time for each group and each individual was calculated by using the lapsed time from when the name was changed on the computer, when the IP address was entered (students were given a range from 10.1.1.2 - 10.1.1.6) and to when PING was used to check for connectivity to other computers on the LAN. This was a very time consuming task as large spreadsheet files had to be carefully reviewed. Figure 22. shows the relevant information for one subject.

12:03:05 PM	David-walker3
12:07:20 PM	10114
12:10:48 PM	ping 10.1.1.3

Figure 22. Calculation of time to connect

Qualitative data were collected through open-ended survey questions. Participants were also randomly video taped in order to compare different treatment group behaviors. The qualitative sources of data were then used to triangulate and corroborate the quantitative results and to add greater insight into our explanations. Additionally, we hope to analyze the video in greater detail to learn through discovery new insights that can only be revealed by observing participants working on tasks within the CSCLIP environment.

6.7 Internal Validity

This study had a reasonable high level of internal validity in that subjects were randomly assigned to either remote or local groups. The study took place over a reasonably short period of time, eliminating concerns about history, maturation, and differential mortality. Equalization of treatment was not a concern because subjects that were not placed in a remote group were offered the opportunity to use the virtual cabling system after the study was completed. Instrumentation was very straightforward and during the unstructured observations, researchers were very familiar with the hardware, software, and overall lab environment and had a great deal of consistency.

6.8 External Validity

External validity to other lab environments should be achievable. The use of senior level MSIS students as subjects enhances external validity because they are very similar to the target population of MSTM students, for which the system has been developed. Many MSTM students enter the program with very good computer skills. Since this work is new and largely untested, much work in the future will need to be done before making the determination that CSCLIP has external validity.

CHAPTER 7.
RESULTS

While it is customary to use MANOVA when there are multiple dependent variables, in this case they were not correlated, so univariate tests were conducted on each hypothesis and the results are shown below.

7.1 Analysis of Hypothesis 1

Means and standard deviations were calculated for score difference. Score difference was calculated by subtracting the pre-test score from the post-test score. Both pre- and post-tests were worth 10 points each. The mean score differences range from 3.1875 to 4.0870 points, with and overall average of 3.6207 points. Standard deviations range from 1.7298 to 2.2439, with an overall average of 1.9451. The total number of subjects for this test was 58. Local students had the highest mean score and the lowest standard deviation, as shown in Table 1.

Table 1. Means and standard deviations for Hypothesis 1

Means and standard deviations for pre and post-test score differences			
Group Type	**Mean**	**N**	**Std Deviation**
F2F	3.1875	16	1.8337
Local	4.0870	23	1.7298
Remote	3.4211	19	2.2439
Total	3.6207	58	1.9451

A one-way analysis of variance (ANOVA) was then used to compare the mean score difference for each group. This test was not significant at $F(2, 55) = 1.164$, at as significance level of 0.05, hence H1 cannot be rejected. That is, there is no statistical significant difference in the cognitive test score gains across the three groups. Table 2 provides the statistical significance results.

Table 2: ANOVA statistics for Hypothesis 1

ANOVA cognitive pre and post-test score differences					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	8.760	2	4.380	1.164	0.320
Within Groups	206.895	55	3.762		
Total	215.655	57			

While not statistically significant, students who participated locally with a remote group scored 28% higher on the post-test minus pretest score difference when compared to students who participated in a F2F group. Remote students scored an average of 7% higher than those in a F2F group. See Figure 23.

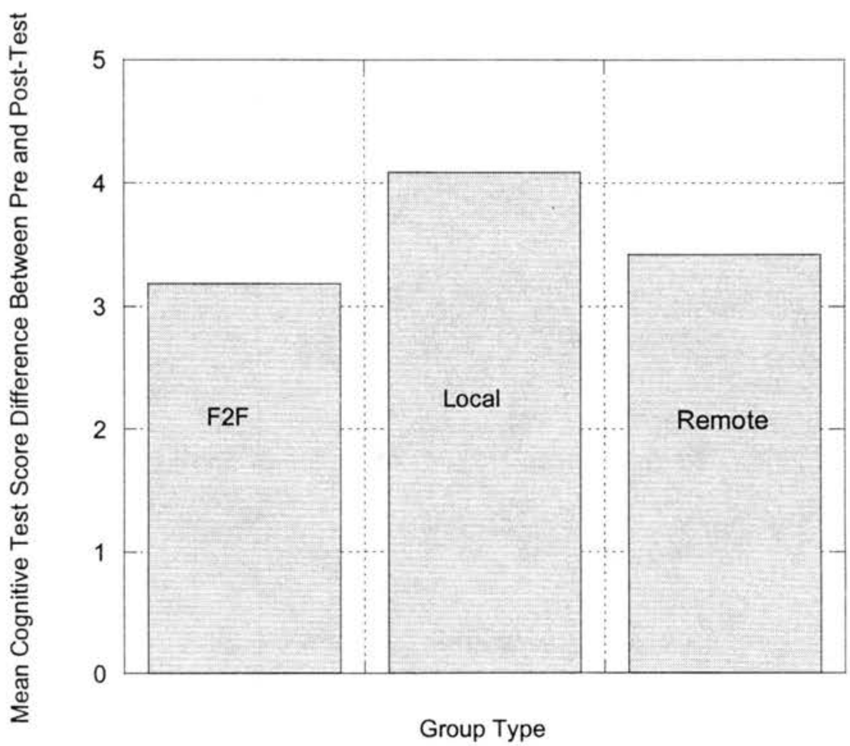

Figure 23. Mean score differences: not significant

This is practically significant in terms of learning outcomes, because in a typical class this would be the difference between a letter grade of A and B on a test or any assignment. Those that participated as remote students scored 3% higher than the F2F group. A plausible explanation is that the highly visual and interactive CSCLIP environment enhances learning by requiring students to stay more focused on the task, thus generating more and better problem solutions which lead to a better cognitive understanding of the task. Another possible explanation is that local and remote groups knew they were being observed, which might have discouraged them from social loafing.

Support for the findings related to hypothesis 1 can be found from several sources. Alexander and Smelser (Alexander 2003) conducted a distance delivery mechanics lab and found student learning was at least equivalent to the traditional lab class. In an analysis of 248 research studies, Russell (Russell 2003) found no significant difference in grades or final evaluations between students in traditional classrooms when compared to those in DL environments. Rovai (Rovai 2003) cites Moore et al. (Moore 1990) and Verduin and Clark (Verduin 1991) as finding that teaching and studying in a DL environment can be as effective if the methods and technologies are appropriate for the task, and that there is sufficient student-to-student interaction. Francis and Tan (Francis 1999) looked at familiarizing flight controllers and other technicians with the appearance and use of various components of the Hubble Space Telescope. They concluded that users found that visualizing activities enhanced understanding and had a positive effect on comprehension of activities and objects.

7.2 Analysis of Hypothesis 2

Means and standard deviations were calculated for individual satisfaction. Individual satisfaction was obtained from the self-report survey described in Section 6.6. The means range from 4.0714 to 4.4341, with an overall average of 4.2768. Standard deviations range from 0.4234 to 0.5869 with an overall average of 0.5442. The total number of subjects for this test was 72. Remote subjects had the lowest mean and the highest standard deviation, as shown in Table 3.

Table 3. Means and standard deviations for Hypothesis 2

Means and standard deviations for individual satisfaction			
Group Type	**Mean**	**N**	**Std Deviation**
F2F	4.3393	20	.4234
Local	4.4341	26	.5364
Remote	4.0714	26	.5869
Total	4.2768	72	.5442

A second ANOVA compared the mean individual satisfaction for each group. This test was significant at $F(2, 69) = 3.264$, at a significance level of 0.05. Table 4 presents the statistical results.

Table 4. ANOVA statistics for Hypothesis 2

ANOVA individual satisfaction					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	1.818	2	0.909	3.264	0.044
Within Groups	19.212	69	0.278		
Total	21.030	71			

A Tukey's pair wise comparison test was then run and a significant difference was found between the local and remote groups, as shown in Table 5.

Table 5. Tukey results for Hypothesis 2

Results of Tukey HSD test		
Group Type	**Group Type**	**Significance**
F2F	Local	.818
	Remote	.210
Local	F2F	.818
	Remote	.041
Remote	F2F	.210
	Local	.041

H2 is supported as local groups had the highest level of satisfaction with a mean of 4.43 compared to F2F groups, which had a mean of 4.33, and remote groups, which had a mean of 4.07. See Figure 24.

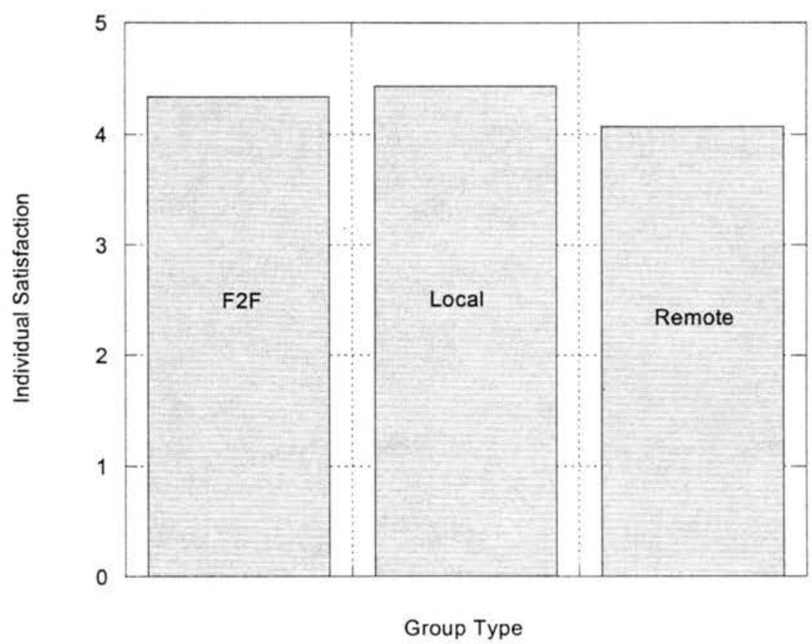

Figure 24. Mean individual satisfaction: significant between local and remote: not significant between F2F and local and F2F and remote

One possible explanation is that the rich medium increased synergies resulting in greater satisfaction. Other factors that could explain the high level of satisfaction among local groups include more complex task accomplishment, task novelty, and a greater sense of engagement or flow.

Studying distributed groups is extremely complex and there is a mixture of reported results regarding satisfaction. Early work by Hiltz (Hiltz 1994) supports this hypothesis and indicates higher levels of student satisfaction in a virtual classroom experiment conducted at New Jersey Institute of Technology. Support for H2 can also be found in Alavi (Alavi 1994). She asserts that students' affective reactions in a computer-mediated collaborative learning process were more positive than those using a manual collaborative process. She also found that those using the computer mediated collaborative environment had perceived higher levels of skill development, learning and interest in learning when compared to those who did not use the system.

The level of satisfaction with remote students was addressed by Ogot et al (Ogot 2003) in a study of a remotely operated mechanical engineering lab. They found that remote students had less satisfaction with their results, however, they actually performed as well as the students who participated in the traditional lab. In a Web-based course offering, Motiwalla and Tello (Motiwalla 2000) found that remote students were dissatisfied with the technology, but overall found the course experience positive. This is in line with our findings, in that remote students had the lowest level of satisfaction, there was no correlation between remote user satisfaction and performance completing the task.

7.3 Analysis of Hypothesis 3

Means and standard deviations were calculated for individual time to complete the task. Time was calculated from the time the computer name was changed to the final PING as was shown in Figure 22. The means range from 14.37 to 16.00, with an overall average of 14.94. Standard deviations range from 4.02 to 6.93, with an overall average of 5.46. The total number of subjects for this test was 70. F2F subjects had the lowest mean and the lowest standard deviation, as shown in Table 6.

Table 6. Means and standard deviations for Hypothesis 3

Means and standard deviations for individual time to complete task			
Group Type	**Mean**	**N**	**Std Deviation**
F2F	14.37	19	4.02
Local	14.41	27	4.89
Remote	16.00	24	6.93
Total	14.94	70	5.46

A third ANOVA compared the mean time to complete the task for each subject. The test was not significant at F(2, 67) at a significance level of .05. Table 7 displays the ANOVA results for Hypothesis 3.

Table 7: ANOVA statistics for Hypothesis 3

ANOVA Individual Time to Complete Task					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	40.832	2	20.416	0.679	0.511
Within Groups	2014.940	67	30.074		
Total	2055.771	69			

H3 is supported in that there is no difference in the time to complete the task individually, regardless of whether the skill was learned in a F2F group, a local group, or a remote group. An interesting comparison can be drawn; while those that learned the task in a F2F group have the overall lowest times, their mean time actually increased by 1.37 minutes when they completed the task individually. The opposite is the case for those students who learned the task in either a local or remote setting as their mean task completion time was reduced by 3.48 minutes and 1.89 minutes respectively.

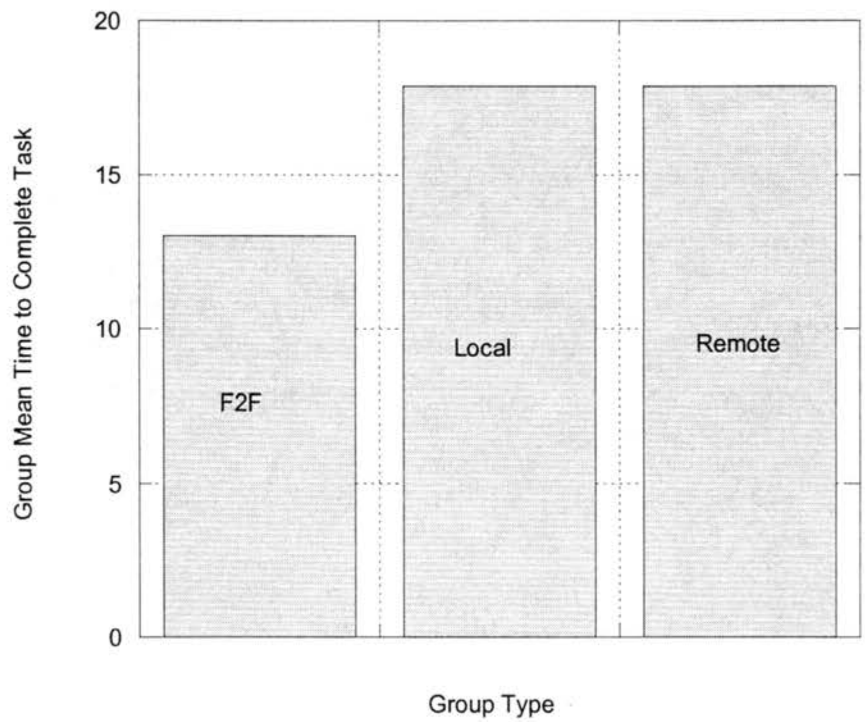

Figure 25. Group mean time to complete task

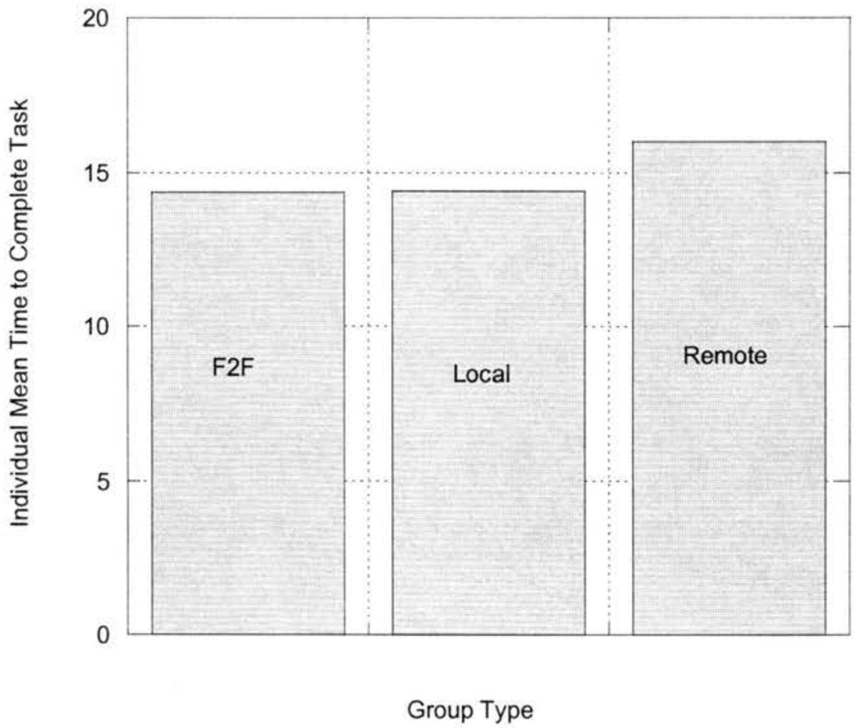

Figure 26. Individual mean time to complete task: not significant

While not statistically significant, one possible explanation could be less domination and social loafing while the skill was first being learned. Also the remote students received specific positive and negative feedback throughout the process. Local students in the CSCLIP group were exposed to this same feedback via desktop sharing, but the F2F students did not receive such feedback from the system. Feedback may motivate skill acquisition and strengthen the learning experience. A higher level of focus was required for remote students resulting in a more intense experience, increased synergies, and greater task understanding.

Support for H3 can be found in Agazio et al. (Agazio 2002). They used participants to study an improved method of training health care workers that provide aid to bio-terrorism victims. Participants were tested using protective clothing with some using an Intravenous (IV) simulator and others using a conventional IV arm model. No significant difference on success rates was found. Using a real-time surgical simulator, Montgomery et al. (Montgomery) found the effect of working in a virtual environment is similar to working on real patients in the operating room and compares favorably with existing training methods. Riva et al. (Riva 1998) studied the possibility of using VR in the study of rehabilitation to measure and monitor responses made by the patient. They found that final performance on the real world task benefited as much from VR as from actual practice.

7.4 Post Hoc Analysis

In addition to the cognitive, affective, and psychomotor outcomes that were assessed, a large amount of demographic data was also collected, which also provides some note worthy insights into CSCLIP. A number of correlations were calculated to identify relationships between the demographic data and the outcome variables. These are discussed below.

7.4.1 Gender

Gender was not correlated with score difference, satisfaction, or total time to complete the task. Male subjects had an average score difference of 3.7 points and female students had an average of 3.4. Females were slightly more satisfied with an average of 4.32, while males had an average of 4.2. Males did worse in the time to complete the task at 15.24 minutes, and females at 14.16, a difference of 7 percent. CSCLIP appears to be relatively gender neutral, which speaks well of the design.

Because the task was highly structured and females performed better, it would be interesting to test a less structured task and compare differences.

7.4.2 Age

There was also no correlation between age and any of the three outcome variables. Ages ranged from 19 to 41. Subjects in the 22-year-old age group showed the highest score difference of 4.28 points while older students (35-41) only had an average of a 2 point increase. Overall, older students had a higher level of satisfaction, with all ages over 26 being higher than the mean of 4.3. With respect to time, scores were evenly distributed around the mean of 15.07 minutes.

7.4.3 Experience

Previous experience was self-reported on a scale of 1 through 4. The choices were novice, occasionally used computers, frequently used computers, and used computers in their profession. Experience was correlated with score difference at 0.778 and satisfaction at 0.87. Those with less experience had an average increase of 4 points on score difference, while those with more experience had an average increase of 3.4 points. This is an indication that the lab adds value, especially to those who have not worked extensively with technology. Also, those subjects with less experience were more satisfied with a mean of 4.40 than the more experienced subjects, having a mean of 4.19. Those that rated themselves "frequently used computers" did best in total time at 13.59 minutes compared to those that rated themselves as professional at 14.26 minutes. The task performed was rather easy, so it will be important as CSCLIP develops to include more complex tasks that also engage the more experienced students. As CSCLIP theory matures, predictors for student success need to be identified and age and experience might be key variables to be tested.

7.4.4 Grade Point Average (GPA)

GPA was correlated with total time at 0.921, but not with score difference or satisfaction. Self-reported GPAs ranged from 2.0 to 3.7. The student with the 2.0 GPA had the highest score difference of 7 points, while the students at the 3.6 GPA and above had an increase of 3 points, which was below the average of 3.48. Satisfaction was evenly distributed around the mean. Most students with a 3.0 GPA and above performed at a faster time than the average of 14.76 minutes. It appears that in this case, the poorer students benefited most and that CSCLIP effected their understanding very positively. The target group of users of CSCLIP is the MSTM students, which tend to have high GPAs and are highly motivated. CSCLIP needs to accommodate a wide range of students, but keeping good students challenged will be an important consideration. Related variables, that when tested, could add insight to future development include learning style and self-efficacy.

7.4.5 English as a First Language (EFL)

EFL was a binary variable with the response choices being either yes or no. There was no correlation with any of the three outcome variables. Subjects that reported EFL had a mean score difference of 3.75 points, while those that were non-native speakers had a score difference of 3.15. EFL subjects were only slightly more satisfied with a mean of 4.31, with the non-native speaking subjects having a mean of 4.17. EFL subjects did better than non-native speaking subjects with respect to time to complete the task. EFL students had an average time of 13.87 minutes compared to the 18.06 minutes it took the non-native speaking subjects to complete the task. This is an important finding, especially as CSCLIP tries to generalize to other domains and cultures. Several possibilities for improvement come to mind. First, more graphical representation in the task structure might be beneficial. Second, reducing verbal interaction and replacing it with chat might improve overall communication.

7.5 Discussion

Within the DL domain there have been many different variables analyzed with differing results. These include variables such as socialization for nursing, content understanding, test performance, grades, homework, attitudes, and achievement. (Souder 1993; Morrissey 1998; Schutte 1998; Navarro 1999; Maki 2000; Stinson 2000; Nesler 2001). They all found significant statistical differences supporting DL. Other studies found statistically significant differences that do not support DL (Hammond 1997; Efendioglo 2000; Stinson 2000). The studies in this group tested the variables of grades, course satisfaction, attrition, and "would not recommend to a friend" for measurement. There are an even larger number of studies that found no significant difference between F2F and DL environments (Gehlauf 1991; Blackley 1998; McAlpine 1998; Ward 1998; Wisher 1998; Schulman 1999; Smeaton 1999; Wade 1999). Variables analyzed in this category include achievement, faculty perceptions, test scores, student satisfaction, and cost effectiveness.

While the present study falls for the most part in the no significant difference category, some interesting observations can be made from the data collected. According to our expectations, CSCLIP fostered the development of psychomotor skills. An interesting observation is that while the remote groups had the highest mean time to complete the task, the actual lowest time to complete the task was 7 minutes and was achieved by a remote student. The next shortest time was 8 minutes, which was accomplished by two subjects – one local and one remote.

The most obvious finding was that in the cognitive and affective outcomes, the local students scored higher than their F2F or remote counterparts. CSCLIP is an unfamiliar learning environment that uses relatively complex technology. These findings are similar to Alavi's (Alavi 2002) and suggest that subjects went through a technology sense-making period, which in turn improved their cognitive understanding, and lead to better satisfaction with the learning process.

Overall, remote subjects reported the lowest level of satisfaction. In open-ended questions, however, many of their comments were very positive:

- The simulation software was informative.
- A worthwhile exercise.
- I learned a lot in this lab.
- The lab software was great.
- I enjoyed the lab. It should be held more often.
- I loved this lab!! Do more of these!!
- It was a great learning tool.

Video taken during the course of the experiment will be used to add qualitative insight into this apparent anomaly.

The results of the present study suggest that there is an impact on learning. The ultimate goal of the lab is to prepare students with the needed skills for a highly technical field. It makes sense that students will learn these skills when they interact in a focused, interactive environment. Kearsley (Kearsley 2000) argues that it is the quality of the design and how well it is delivered, not if they are F2F that makes it a successful learning experience.

The key research question is: Does CSCLIP effectively use technology and incorporate learning experiences that are meaningful in a real world setting? The answer is that after initial testing, it shows much promise for providing convenience and flexibility for learning hands-on lab skills.

7.6 Limitations

Due to the exploratory nature of this study, there are some limitations. First, a small sample size was used, limiting power and effect size. Only 17 groups were compared with four subjects in each group. Reducing alpha would help and might be appropriate in this early stage of investigation. Another limitation is that the task was relatively simple and the groups interacted over a short period of time. A third limitation is that the study focused on undergraduate students at one institution. To make this work more generalizable it may be useful to use students different levels at multiple universities as subjects, while controlling for issues such as instructor variance, student experience, etc.

Despite these limitations, this study provided much insight into the complexities of testing a CSCLIP environment. Although power and statistical significance are important, it would be unwise to abort this promising line of research based only on statistical findings. Practical conclusion validity can be achieved through good experimental implementation and the use of observational data to draw inferences. It is also important to consider previous research and theory when attempting to explain the variance.

CHAPTER 8.
CONCLUSIONS

The initial results from this first proof of concept CSCLIP experiment are very positive. There are a number of factors that added to the success of this experiment. First, thorough pilot testing was conducted. From these early tests it was found that a high level of structure was needed to guide subjects to task completion. The actual instructions used during the experiment can be found in the Appendix. Second, there was excellent technical support from a number of highly skilled MSTM students throughout the entire six days over which the experiment was run. Third, the virtual cabling software developed specifically for this experiment was well tested and very robust. Finally, key stroke and screen shot data was collected from each subject after each session was completed and was systematically organized, making the analysis more efficient.

The important finding is that no significant difference between learning psychomotor skills in a F2F setting, locally, or remotely exists. The encouraging results from this early work indicate that we should move forward with this research stream. Technology, task, and process support and structure need to be developed and assessed for more complex tasks that are carried out over longer time periods and with a larger number of participant groups. Lessons learned from this first assessment will help us to design new experiments. This is important in CSCLIP research, because such experiments are very complex to design and implement, and future lab modules will need to be highly structured and carefully pilot-tested with technical support staff readily available before and during experimental treatments.

Video taping the participants also provides a potential wealth of qualitative data for discovery of new insights using protocol analysis. In addition the keystroke and screen capture data is voluminous and needs to be methodically organized and analyzed for patterns and trends that may also yield unexpected clues and results that will inform the design of future CSCLIP environments and tasks.

The findings from this study could have even broader implications. CSCLIP technology has the potential to reduce and possibly eliminate the need for student travel. The convenience and flexibility of CSCLIP will attract more and better students, thus improving instructor efficiency. CSCLIP has been shown to be both practical and possible and could change the way the lab course is structured, enabling shorter learning opportunities. Currently the lab is held from 8am to 5pm for four consecutive days, often resulting in information overload. Shorter learning modules held on a weekly basis may improve understanding in all learning domains and improve trust and collaborative activities among group members.

Another important consideration as we move forward to make CSCLIP more generalizeable to other domains is the identification of other variables that might be more germane to CSCLIP. These could include instructor variables, user experience level, user learning style, online communication, technical support, and course design.

Collaboration and collaborative learning do not occur *merely* because people are electronically connected. Virtual labs and their coordinating technologies are providing a framework that extends our understanding how best to educate in the eLearning era beyond the classroom into hands-on tasks and experiences. A cross-disciplinary perspective combined with careful examination of the necessary components of a successful system will provide the basis for advances in virtual lab development.

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APPENDIXES

APPENDIX A
PRE- AND POST-TEST QUIZ

Ethernet LAN Quiz

1. Which of the following statements best describes Ethernet?
    a. Logical bus topology over a physical star
    b. Logical ring topology over a physical star
2. IEEE 802.3 protocols define which of the following
    a. Token Ring media access
    b. CSMA/CD
    c. ALOHA
    d. Slotted ALOHA
    e. FDDI and ATM
3. In a contention MAC
    a. only one NE can access the medium at a time in a specific order
    b. multiple NEs can access the medium at one time in any order
    c. only one NE can access the medium at a time but only when it hold the token
    d. none of the above
4. In IEEE 802.3 protocols, when the NE senses the medium is busy what does it do
    a. Wait to transmit until a clear connection is detected.
    b. Transmit any way allowing the receiver to interpret the correct signal.
    c. Send multiple copies of the message in the hope that one will successfully reach the destination
5. Why does IEEE 802.3 actually work?
    a. Because propagation time is much less than transmit time.
    b. Because transmit time is much less than propagation time.
    c. Because propagation time is equal to the transmit time.
    d. Because the sender and receiver of the message are on the same LAN.
6. What does the term BASE in 100BASET mean?
    a. one message occupies all the bandwidth
    b. baseband
    c. all the bandwidth is composed of many signals via some type of multiplexing
    d. a and b
    e. b and c
    f. none of the above
7. Ethernet addresses are an example of
    a. WAN routing addressing based on OSI network layer specifications.
    b. Link level addressing based on the OSI data link layer, sublayer MAC specifications.
8. The purpose of a HUB in a LAN is to
    a. connect all NEs so that they can share the medium
    b. allows sharing of the medium so that the throughput of the system can be increased.

    c. Allows the creation of a hierarchy of connections
    d. All of the above
    e. None of the above
9. A switched HUB
    a. will broadcast all frames it receives out all ports.
    b. will broadcast all frames out all ports except the one it came in on.
    c. will read the frame addresses and send out the appropriate port.
    d. All of the above
    e. None of the above.
10. The data part of an Ethernet frame can be no larger than
    a. 100 bits.
    b. 100 bytes.
    c. 1500 bits.
    d. 1500 bytes.

APPENDIX B
DEMOGRAPHIC INFORMATION
GROUP SATISFACTION

Please answer the following questions about your background:

I participated in a
__ Face-to-face group
__ Remote group
__ Local member of remote/local group

Gender
__ Male
__ Female

Your age at last birthday: __

Major: ____________________

Undergraduate GPA: _____

Nationality:
__ USA
__ Other

Ethnic Group/Racial Background
__ Black/Afro American
__ Native American
__ Hispanic (Mexican, Puerto-Rican, etc.)
__ White
__ Asian or Asian-American
__ Other

Is English your native or first language
__ Yes
__ No

How would you describe your typing skills?
__ None
__ Hunt and peck
__ Casual (rough draft with errors)
__ Good (25 wpm error free)
__ Excellent (40 wpm error free)

Academic Standing
__ Freshman
__ Sophomore
__ Junior
__ Senior
__ Master's candidate
__ Doctoral candidate
__ Post-doctoral

Which of the following best describes your previous experience with computer systems?
__ I am a NOVICE; seldom or never use computers
__ I have OCCASIONALLY used computer systems before
__ I have FREQUENTLY used computer systems
__ Use of computers is central to my PROFESSIONAL work

Work Experience
Full time _____ years
Part time ______ years

In this section, there are some statements about working with computers. Please indicate the extent to which you agree or disagree with each statement by circling the first response that you feel or think is best:
5=Strongly Agree
4=Agree
3=Neither Agree nor Disagree
2=Disagree
1=Strongly Disagree

My friends often say I am obsessed with computers.	1 2 3 4 5
I often spend hours tinkering around with computer equipment or software.	1 2 3 4 5
Much of what I know about computers I learned informally from my friends.	1 2 3 4 5
I'm always spending money on computer-related products.	1 2 3 4 5
I often lose track of time when using or playing around with computers.	1 2 3 4 5

In this section, there are some statements that may describe your perceptions on your group. Please decide how much you agree with each statement. Use the following scale and circle the best response to each statement

5=Strongly Agree
4=Agree
3=Neither Agree nor Disagree
2=Disagree
1=Strongly Disagree

1. I want to remain a member of this group.	1	2	3	4	5
2. I like my group.	1	2	3	4	5
3. I feel involved in what is happening in my group.	1	2	3	4	5
4. If I could drop out of the group now, I would.	1	2	3	4	5
5. I dread coming to this group.	1	2	3	4	5
6. I wish it were possible for the group to end now.	1	2	3	4	5
7. I am dissatisfied with the group.	1	2	3	4	5
8. If it were possible to move to another group at this time, I would.	1	2	3	4	5
9. I feel included in the group.	1	2	3	4	5
10. In spite of individual differences, a feeling of unity exists in my group.	1	2	3	4	5
11. Compared to other groups I know of, I feel my group is better than most.	1	2	3	4	5
12. I do not feel a part of the group's activities.	1	2	3	4	5
13. I feel distant from the group.	1	2	3	4	5
14. I feel my absence would not matter to the group	1	2	3	4	5
15. I look forward to coming to the group.	1	2	3	4	5

APPENDIX C
INDIVIDUAL SATISFACTION

Name________________________

Peer-to-Peer 10BaseT LAN

Please mark appropriate response regarding this lab.

	Very High	**High**	**Average**	**Low**	**Very Lo**
Preparation and organization	( )	( )	( )	( )	( )
I learned a lot in this course.	( )	( )	( )	( )	( )
The work load was appropriate	( )	( )	( )	( )	( )
Students were adequately involved.	( )	( )	( )	( )	( )
This lab was worthwhile to me.	( )	( )	( )	( )	( )
Overall, this was a good lab.	( )	( )	( )	( )	( )

In this section, there are some statements that may describe your perceptions on the lab. Please decide how much you agree with each statement. Use the following scale and circle the best response to each statement. **1=Strongly Disagree; 5=Strongly Agree**

I feel satisfied with the lab itself.	1 2 3 4 5
I believe adequate directions were given with the lab.	1 2 3 4 5
I feel I was given adequate information on how to configure the lab.	1 2 3 4 5
I am satisfied with my performance in the lab.	1 2 3 4 5
I learned a lot from the lab.	1 2 3 4 5
The lab was similar to a real world setting.	1 2 3 4 5
I enjoyed the lab.	1 2 3 4 5
I found the lab interesting.	1 2 3 4 5

Please comment on the following items regarding this lab.

1. Lab Hardware:

2. Lab Software:

3. Lab Setting

4. Lab Instructions:

5. Other Comments:

6. Suggestions for improving the lab:

APPENDIX D
LOCAL/REMOTE TASK INSTRUCTION

TCOM5012
Peer-to-Peer 10BaseT LAN

Prof. Mark Weiser

Introduction:

This lab duplicates the way an organization might initially install computer data networks as small isolated islands called local area networks (LANs). We will be experimenting with a Windows based peer-to-peer network. We've selected this LAN operating system because it comes installed with most computers free of charge. In later labs, the individual LANs will then be connected through routers, an FDDI ring, and ATM, allowing connectivity with other benches and the Internet.

Objectives:

1) Become familiar with some of the capabilities of an Ethernet peer-to-peer LAN.
2) Become familiar with some of the duties of a peer-to-peer LAN Network Administrator.
3) Develop basic LAN trouble-shooting skills.

Pre-Lab:

1) Read this handout.
2) Review your notes from previous classes regarding the operation of 10BaseT Ethernet, hubs, and routers, including IP networking.
3) Learn to use Net meeting software, and learn to do desktop sharing using it.
4) It is assumed that you are familiar with desktop sharing, otherwise goto: http://mstm.okstate.edu/~vlab/mainframe.htm to read the PC based video conferencing.

Rules of Engagement:

During the hands-on portion of this lab, team members will receive identical scores based on how many tasks the team successfully accomplishes. If you get stuck, first try your teammates for assistance. If necessary, feel free to ask a TA or Professor for help. The entire group must have completed the exercises on each of their computers prior to any group member being signed off. *You are not allowed to ask other teams for aid.*

Experiments

Each group will be assigned to a separate room. Head to your assigned location, introduce yourself to the other member(s) of your team, and select a computer for each person.

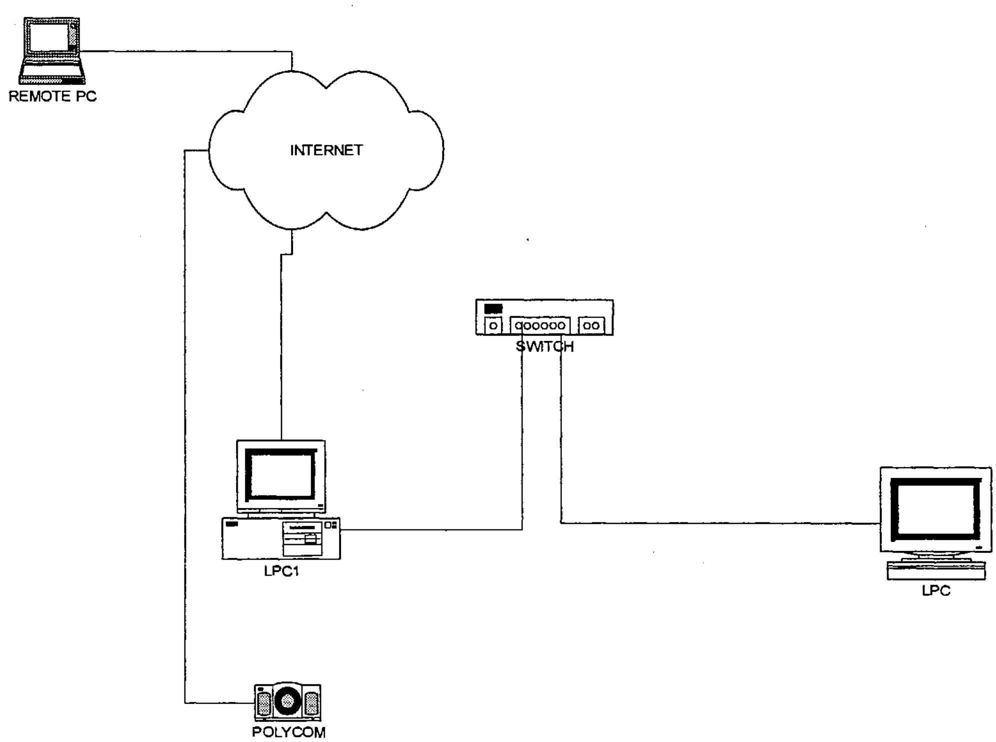
POINTS TO REMEMBER:

!!!!!!!!Work in parallel with each other; try to work as a group.

REMOTE STUDENT	LOCAL STUDENT
Student 1: 1. Connect to the polycom camera in the local room using Netmeeting. To do this double click on the Netmeeting icon located in the top right hand corner of your screen Enter the IP address. If you are in Room D the number is 139.78.9.248 If your are in Room C the number is 139.78.9.249 Then click the telephone icon.	1. Wait for the remote student to connect.
2. Watch the local students make their physical connections as in the network diagram on page3. They will connect If you have any questions about what they are doing **ASK**!	2. Connect the LPC1 to the switch through the NIC (LAN2). Also connect the other computers to the switch as in the network diagram on page3. If the connection from the PC to the switch is proper then a light glows above the port where the cable is connected.
3. You need to give the local students the IP address of your computer - Go to Start -> Run -> Type cmd - Click Ok This will take you to a DOS prompt - Type "ipconfig" to obtain the ip address.	3. You need to give the remote students the IP address of the computer having two NIC card Ethernet ports (Local PC 1) - Go to Start -> Run -> Type cmd - Click Ok This will take you to a DOS prompt - Type "ipconfig" to obtain the ip address. Give the ip address of "Ethernet adapter Local Area Connection"
4. Obtain the IP address of the local PC by asking the local students.	4. Obtain the IP address of the remote PC by asking the remote students

5. Share your desktop by going to: Goto Start →Programs → TightVNC → Launch TightVNC server - Ask the local students if they finished sharing your desktop in order to proceed to the next step.	5. Share the remote desktop by going to: - Start →Programs → TightVNC → TightVNC Viewer (Best compression) - Type in the remote IP address - Type in the password: "mstm".
6. Now you are going to use the "vlab" software in order to do your virtual cabling. - Click on "Shortcut to Vlab" icon on your desktop (located just below the Netmeeting icon) Follow the steps on the vlab software.	6. Watch the remote user using the software. - After they submit their virtual connection **watch the other switch (not the one you connected) at port 12** and describe what is happening to the remote person. -After the remote student finishes doing the virtual cabling close the **remote user desktop.**

PEER-TO-PEER LAN CONNECTION



Physical Connections: Remember to connect the computers in the Local Network to the same HUB, the computers are connected using the Ethernet ports having the static

IP addresses that you will assign in the later part of the lab.

REMOTE STUDENT	LOCAL STUDENT
7. Share the local desktop by going to: - Start →Programs → TightVNC → TightVNC Viewer (Best compression) - Type in the local IP address - Type in the password: "mstm".	7. Share your desktop by going to: Goto Start →Programs → TightVNC → Launch TightVNC server - Ask the remote student if he finished sharing your desktop in order to proceed to the next step.
Software Configuration: **Student 2**: 8. The next task we will tackle is to properly set up Windows so that all three computers of your group can 'see' each other.	**Software Configuration:** 8. The next task we will tackle is to properly set up Windows so that all three computers of your group can 'see' each other.
- Users must change the name of the local computers. You could actually name the computer anything you want, but for this lab we want you to use your full name using the hyphen to separate the names (e.g. John-Smith or Jane-Doe).	-Users must change the name of the local computers. You could actually name the computer anything you want, but for this lab we want you to use your full name using the hyphen to separate the names (e.g. John-Smith or Jane-Doe).
- Remote students will change the name of Local PC 1 by using the shared desktop. - Right click on the "My Computer" icon. - Properties -> Network Identification -> Properties -> Computer Name - Change the name of the computer to your first and last name, separated by using the hyphen key. - You can name your workgroup anything you like, but all computers on the LAN must have **the same Workgroup name**. - Click "OK" - Click "OK" - You will then need to reboot the **Local PC 1** on the shared desktop not yours.	- Local students will change the name of Local PC 2. - Right click on the "My Computer" icon. - Properties -> Network Identification -> - - Properties -> Computer Name - Change the name of the computer to your first and last name, separated by using the hyphen key. - You can name your workgroup anything you like, but all computers on the LAN must have **the same Workgroup name**. - Click "OK" -Click "OK" - You will then need to reboot.
9. You will lose connection so you must repeat **step 7** in order to share the local desktop again by using Tight VNC.	9. You will lose connection so you must repeat **step 7** in order to share your desktop again by using Tight VNC.

Student 1:	On local PC 2:
Student 1: 10. **Using the shared desktop:** - Now you must assign a static IP address or the local PC 1. - Right click on the "My Network Places" icon on the shared desktop. - Then go to -> properties -> select LAN2(**The NIC you are not connected to...double check to see if the IP address currently shown in that LAN is not what you are connected to using TightVNC**) and right click -> properties -> select TCP/IP -> properties -> check and use the following IP address option and then assign the IP address.	10. **On local PC 2:** - Now you must assign a static IP address for the local PC 2. - Right click on the "My Network Places" icon. - Then go to -> properties -> select "Local Area Connection" and right click -> properties -> select TCP/IP -> properties -> check and use the following IP address option and then assign the IP address.
Each machine must have a **different IP address**; make sure you are not using the IP the local students have chosen.	Each machine must have a **different IP address**; make sure you are not using the IP the remote students have chosen.
- You can choose either 10.1.1.2 10.1.1.3 10.1.1.4 10.1.1.5 10.1.1.6	- You can choose either 10.1.1.2 10.1.1.3 10.1.1.4 10.1.1.5 10.1.1.6
- Your subnet mask is 255.255.255.248 - Your Gateway is 10.1.1.7 - The IP address for the DNS is 139.78.100.1 - Click OK - Click OK	- Your subnet mask is 255.255.255.248 - Your Gateway is 10.1.1.7 - The IP address for the DNS is 139.78.100.1 - Click OK - Click OK
11. Now Check to see if your LAN is functioning, using PING. PING stands for Packet Internet Groper, and is used to test for connectivity.	11. Now Check to see if your LAN is functioning, using PING. PING stands for Packet Internet Groper, and is used to test for connectivity.
Always on the shared desktop: - Go to Start -> Run -> Type cmd This will take you to a DOS prompt. Type ping and the number of the other computers on your LAN (e.g. ping 10.1.1.3)	**On local PC 2:** -Go to Start -> Run -> Type cmd This will take you to a DOS prompt. Type ping and the number of the other computers on your LAN (e.g. ping 10.1.1.3)

<u>Always on the shared Desktop:</u> - Next go to the "My Network Places" icon -> Computers Near Me. - You should be able to view all the computers on the LAN **Student 2:** **<u>Always on the shared Desktop:</u>** -You must now change the name of the computer to your name, give it a different IP address, and add the Alternate DNS Server – 139.78.200.1 **<u>Always on the shared Desktop:</u>** - Now Check to see if your LAN is functioning, using PING. PING stands for Packet Internet Groper, and is used to test for connectivity. Got to Start -> Run -> Type cmd This will take you to a DOS prompt. Type ping and the number of the other computers on your LAN (e.g. ping 10.1.1.3) **<u>Always on the shared Desktop:</u>** - Next go to the "My Network Places" icon -> Computers Near Me. You should be able to view all the computers on the LAN	**<u>On local PC 2:</u>** -Next go to the "My Network Places" icon -> Computers Near Me. - You should be able to view all the computers on the LAN

APPENDIX E
INDIVIDUAL TASK INSTRUCTIONS

Peer-to-Peer 10BaseT LAN

Introduction:
This lab duplicates the way an organization might initially install computer data networks as small isolated islands called local area networks (LANs). We will be experimenting with a Windows based peer-to-peer network. We've selected this LAN operating system because it comes installed with most computers free of charge.

Objectives:
1. Become familiar with some of the capabilities of an Ethernet peer-to-peer LAN.
2. Become familiar with some of the duties of a peer-to-peer LAN Network Administrator.
3. Develop basic LAN trouble-shooting skills.

Pre-Lab:
1. Read this handout.
2. Review your notes from previous classes regarding the operation of 10BaseT Ethernet, hubs, and routers, including IP networking.
3. Learn to use Net meeting software, and learn to do desktop sharing using it.
4. It is assumed that you are familiar with desktop sharing, otherwise go to: http://mstm.okstate.edu/~vlab/mainframe.htm to read the PC based video conferencing.

Rules of Engagement:
You are not allowed to ask other teams for aid. If necessary, feel free to ask a TA or Professor for help.

Experiments:
Each group will be assigned to a separate room. Head to your assigned location, introduce yourself to the other member(s) of your team, and select a computer for each person.

I. Physical Connectivity:
1. Connect each of your PC's to a port on your hub. As you plug in each cable to a port, the corresponding light should illuminate, indicating a basic electronic connection with the computer. This assumes that the other end of the cable is connected to the computer, and that the driver for the network card is properly installed. If any of the lights do not illuminate, check to be sure that both ends of the cable are connected. *Note: an electrical connection does not guarantee proper data communications, but it is a requirement for those communications.*

II. Software Configuration:

The next task we will tackle is to properly set up Windows so that all three computers of your group can 'see' each other.
Users must change the name of each computer. You could actually name the computer anything you want, but for this lab we want you to use your full name using the hyphen to separate the names (e.g. John-Smith1, John-Smith2 and John-Smith3).

1. Change the name of the first computer.
2. Right click on the "My Computer" icon.
3. Go to Properties -> Network Identification -> Properties -> Computer Name
4. Change the name of the computer to your first and last name, separated by using the hyphen key and ending with the number of the computer (e.g. John-Smith1, John-Smith2 and John-Smith3).
5. Name your workgroup anything you like, but all computers on the LAN must have the same Workgroup name.
6. Click "OK"
7. Reboot your computer.
8. Click "OK"

Now you must assign a static IP address
9. Double click on the "My Network Places" icon.
10. Right click -> properties -> select LAN2 and right click -> properties -> select TCP/IP -> properties -> check the use the following IP address option and then assign the IP address.
You can choose either
10.1.1.2
10.1.1.3
10.1.1.4
10.1.1.5
10.1.1.6
!!!!!!!!!Each machine must have a **<u>different</u>** number

11. Subnet mask is 255.255.255.248
12. Gateway is 10.1.1.7
13. IP address for the DNS is 139.78.100.1
14. Click OK
15. Click OK

Now check to see if the first computer is showing up on the LAN
16. Right Click on "My Network Places" icon -> Double Click on "Entire Network" icon -> Click on "You may also view the <u>entire contents</u> of the Network"
17. Double Click on "Microsoft Window Network" icon
18. Double Click on your workgroup
19. Repeat Steps 1->18 of part II. Software Configuration for the two remaining computer

After configuring all three PC
20. Click on View->Refresh (On the Menu Bar of your current window)

Now Check to see if your LAN is functioning, using PING. PING stands for Packet Internet Groper, and is used to test for connectivity.

21. Got to Start -> Run -> Type cmd
22. Click"OK"

This will take you to a DOS prompt.
23. Type ping and the ip address of the other two computers on your LAN(e.g. ping 10.1.1.3)

Oklahoma State University
Institutional Review Board

Protocol Expires: 2/18/2004

Date: Wednesday, February 19, 2003 IRB Application No BU039

Proposal Title: ENHANCING THEORY AND TECHNOLOGIES TO ENABLE COMPUTER SUPPORTED COLLABORATIVE LEARNING (CSCLIP)

Principal Investigator(s):

Joyce Lucca	Ramesh Sharda
1417 S. Fairfield Dr	321 CBA
Stillwater, OK 74074	Stillwater, OK 74078

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

Dear PI :

Your IRB application referenced above has been approved for one calendar year. Please make note of the expiration date indicated above. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved projects are subject to monitoring by the IRB. If you have questions about the IRB procedures or need any assistance from the Board, please contact Sharon Bacher, the Executive Secretary to the IRB, in 415 Whitehurst (phone: 405-744-5700, sbacher@okstate.edu).

Sincerely,

Carol Olson

Carol Olson, Chair
Institutional Review Board

VITA 2

Joyce A. Lucca

Candidate for the Degree of

Doctor of Philosophy

Thesis: ACHIEVEMENT OF PSYCHOMOTOR SKILLS THROUGH COMPUTER SUPPORTED COLLABORATIVE LEARNING REQUIRING IMMERSIVE PRESENCE (CSCLIP)

Major Field: Business Administration

Biographical:

Education: Received a Bachelor of Science from Indiana University of Pennsylvania in 1978. Completed the requirements for a Master of Science in Telecommunications Management (MSTM), Oklahoma State University, Stillwater, OK, 1998. Completed the requirements of a Doctor of Philosophy, Oklahoma State University, Stillwater, OK, 2003.

Experience: From 1996 through 1998 held the position of teaching assistant for the MSTM lab and for the course ECEN 5553 at Oklahoma State University. In 1998 held the position of instructor for MSIS 4523, Data Communications Systems at Oklahoma State University. From 1999 to present held the position of Center Associate, Institute for Research in Information Systems (IRIS) Oklahoma State University.