4-30-2010

An Examination of Social Presence in Video Conferencing vs. an Augmented Reality Conferencing Application

Travis B. Faas
tfaas@purdue.edu

Graduate School ETD Form 9
(Revised 12/07)

PURDUE UNIVERSITY
GRADUATE SCHOOL
Thesis/Dissertation Acceptance

This is to certify that the thesis/dissertation prepared

By Travis Byron Faas

Entitled An Examination of Social Presence in Video Conferencing vs. an Augmented Reality Conferencing Application

For the degree of Master of Science

Is approved by the final examining committee:

Ronald Glotzbach
Chair

James Mohler

Bill Watson

To the best of my knowledge and as understood by the student in the *Research Integrity and Copyright Disclaimer (Graduate School Form 20)*, this thesis/dissertation adheres to the provisions of Purdue University's "Policy on Integrity in Research" and the use of copyrighted material.

Approved by Major Professor(s): Ronald Glotzbach

Approved by: Gary Bertoline 4/27/2010
Head of the Graduate Program Date

Graduate School Form 20
(Revised 1/10)

PURDUE UNIVERSITY
GRADUATE SCHOOL

Research Integrity and Copyright Disclaimer

Title of Thesis/Dissertation:

AN EXAMINATION OF SOCIAL PRESENCE IN VIDEO CONFERENCING VS. AN AUGMENTED REALITY CONFERENCING APPLICATION

For the degree of Master of Science

I certify that in the preparation of this thesis, I have observed the provisions of *Purdue University Teaching, Research, and Outreach Policy on Research Misconduct (VIII.3.1)*, October 1, 2008.*

Further, I certify that this work is free of plagiarism and all materials appearing in this thesis/dissertation have been properly quoted and attributed.

I certify that all copyrighted material incorporated into this thesis/dissertation is in compliance with the United States' copyright law and that I have received written permission from the copyright owners for my use of their work, which is beyond the scope of the law. I agree to indemnify and save harmless Purdue University from any and all claims that may be asserted or that may arise from any copyright violation.

Travis Faas

Printed Name and Signature of Candidate

04/01/2010

Date (month/day/year)

*Located at http://www.purdue.edu/policies/pages/teach_res_outreach/viii_3_1.html

AN EXAMINATION OF SOCIAL PRESENCE IN VIDEO CONFERENCING VS. AN AUGMENTED REALITY CONFERENCING APPLICATION

A Thesis

Submitted to the Faculty

of

Purdue University

by

Travis Byron Faas

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

May 2010

Purdue University

West Lafayette, Indiana

To Claire, the originator of my studious life, and to Cheryl Faas, a mother who made sure I was where I needed to be.

ACKNOWLEDGMENTS

The author would like to thank Kellen Maicher for the time and effort he put into the ideation and refinement of this document.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Faas, Travis Byron. M.S., Purdue University, May, 2010. An Examination of Social Presence in Video Conferencing vs. an Augmented Reality Conferencing Application. Major Professor: Ronald Glotzbach.

This study focused on the implications of augmented reality videochat when used in an educational context. Traditional web conferencing systems are impaired by limitations that inhibit their use for education, primarily due to their difficulty in creating social presence. An augmented video chat system was created that allowed two users to interact with a three dimensional models displayed on top of paper markers called fiducials. This chat system was tested to ascertain if it was able to create more social presence than a traditional web conferencing system. The two systems were found to create similar amounts of social presence during use. Implications for educational use and future web conferencing systems are discussed.

CHAPTER 1. THE PROBLEM

Augmented reality applications are on the threshold of being ready for practical, mainstream use. The term “augmented reality” was coined in 1990 by University of Arizona professor Tomas Caudell during his time at Boeing (Chen, 2009). He used the term to describe a head-mounted display that could help guide workers as they assembled parts for airplanes. In 1992, Milgram and Kashino further refined the concept of augmented reality by placing it within their mixed reality continuum. They defined augmented reality as a real-time combination of the real world and digital world that contained a majority of data from the real world. By 2008, hardware and software had advanced to the point that users were able to run augmented reality applications in their web browsers and cell phones. In 2009, some of the first augmented reality applications to arrive for mainstream use were the “augmented reality browsers” WikiTude, Layer, and NearestPipe. These applications run on mobile phones and overlay information about the surrounding location on top of live video from the phone's camera.

There is currently a lack of scholarly literature on the effectiveness of applied augmented reality systems, especially concerning the social factors of simultaneous users. The relatively small amount of work previously conducted focused on the perception of mixed-reality space, usability, and educational issues. Recently more systems are being built that have a distinctly social component.

Figure 1.1 Human Pacman.

Human Pacman is one example of an augmented reality game with social components (Cheok, Goh, Liu, Fabiz, Fong, Teo, Li, & Yang, 2003). In this familiar game, users are given mobile computers and take the role of either “Pacman” or an enemy “ghost.” (See Figure 1). As users move about, cameras capture the surrounding environments, which then have game play elements overlaid on top of them. By looking at the environment through the mobile display, the user sees a combination of real and virtual elements that update respectively as they move about in physical space. Similarly, the “ghost players” see the environment from their own unique perspective. Ghosts players chase the Pacman player around town, and must collaborate together in order to capture the Pacman who is completing the level.

Similar games and applications are now being built that highlight the capabilities of augmented reality for use in social ways, such as the Webcam Social Shopper by Zugara shown in Figure 1.2. This program allows users to try on different styles of clothing digitally, and to share the images of the results with friends via FaceBook or email. The clothes are placed on top of the users through computer vision, and users can cycle through different types of clothes through an on-screen interface that is activated by motion detection. Once they find a piece of clothing with which they are happy, they can take several snapshots that can be shared with friends in asynchronous ways. Although the Zugara program does not include real-time interaction with other users, one can easily imagine the video of users trying on clothes being broadcast to others who can provide immediate feedback.

Figure 1.2 Zugara Social Shopper.

Web conferencing systems, such as Adobe Connect and Citrix goToMeeting, could benefit from integrated augmented reality elements. Currently, online meeting systems combine live video with separate panels for supplementary information (such as a PowerPoint presentation).

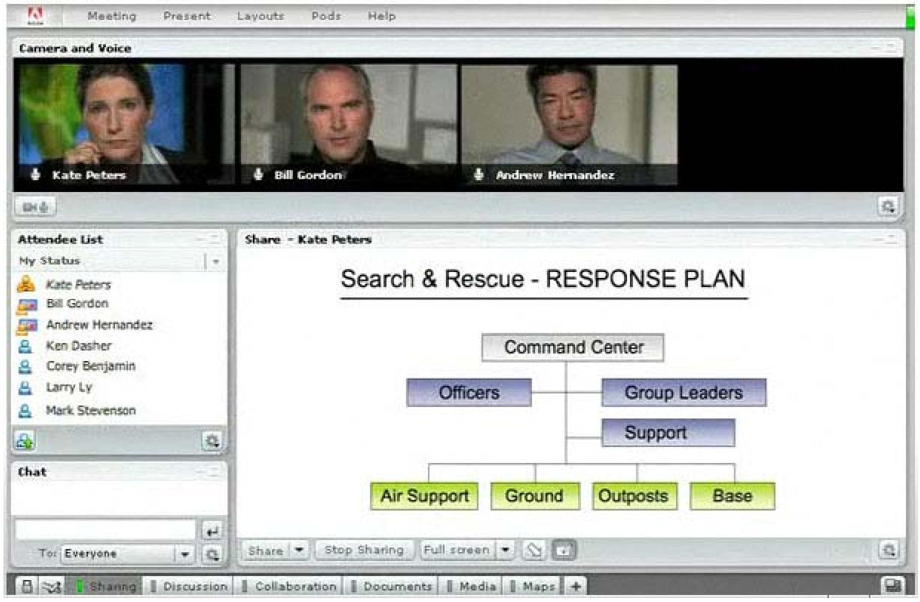


Figure 1.3 Adobe Connect, web conferencing system.

Figure 1.4 Augmented reality videochat.

A typical web conferencing system is set up much like that shown in figure 1.3. In a setup like this, the user video becomes a secondary component, and is used most often to confirm if participants are still paying attention or if they are ready to move on. The loss of video primacy in these systems may lead to less emotional connection between users. Figure 1.4 shows an example of an augmented reality videochat system. These systems can combine both the speaker and more of the complementary material such as graphics or text in the same viewing range, possibly permitting better connection and communication between users.

1.1. Statement of the problem

Video conferencing systems do not provide sufficient social presence when used in an educational setting.

1.2. Significance of the problem

As more students move online to further their education, they need software that supports distance learning. One aspect of many courses is when projects and discussions are done in groups. Although nothing may reach the effectiveness of meeting with group members in person, systems should be developed that encourage users to share ideas and talk in ways that create the highest levels of learning. A strong sense of social presence is required to achieve these strong interactions (So & Brush, 2007). By and large, business communication systems were not designed to provide a strong sense of this presence and use of these systems may result in lessened learner group performance.

Current web conferencing systems are generally not designed specifically for students and educational purposes. Web conferencing systems and many other collaborative technologies are built in order to support business needs (Nari, Whittaker, & Bradner, 2000; Whittaker, Swanson, Kucan, & Sidner, 1997). Often, these systems do not translate well to learning contexts and educational environments. Unlike an office environment where productivity and efficiency is key, educational applications need to create connections between users, allow those users to discuss and explore ideas, and create a good sense of shared knowledge between learners (Ahern et al., 2006). Much work has been done in creating online spaces for learners but one area that has not been thoroughly investigated is online meeting systems.

1.3. Research Questions

This study investigated two questions related to the use of augmented reality and video conferencing applications in online education:

- Does an augmented reality chat application create a stronger sense of presence compared to web conferencing systems?
- Are video conferencing systems or augmented reality conferencing applications better for computer-supported collaborative learning?

1.4. Statement of purpose

This study served as a preliminary exploration of the effects of an augmented reality web conferencing system on collaboration and social presence. Specifically, it examined the amount of social presence generated by an augmented reality conference system during its use.

1.5. Assumptions

These aspects of the study were assumed:

- Participants will make an effort to finish assigned tasks in a timely manner.
- Participants will answer questions accurately.
- A sample drawn from Purdue will represent a general postsecondary population.
- CiTrix GoToMeeting is representative of the gamut of online conference systems.

1.6. Limitations

The study was concerned with only these issues:

- The communication efficiency and affective aspects of the two modes of collaboration.
- Collaboration between only two simultaneous users.
- Less than ten-thousand polygons and flat-shaded three-dimensional models used in the augmented reality system
- Augmented reality using Adobe Flash technology.
- A collaborative setting for the use of augmented reality.
- Gestures used to communicate to others.

1.7. Delimitations

The study specifically will not consider:

- Distance education lectures using augmented reality techniques.
- Alternative recognition technologies such as *Studierstube* or *Reactivision* to augment reality.
- Specific content areas to be taught.

1.8. Definitions

Augmented Reality: A mixed reality with a higher combination of real data than virtual data. (Milgram & Kishimo, 1994).

Common ground: a basis agreed to by all parties for reaching a mutual understanding (Princeton wordnet).

Computer supported collaborative learning: "an emerging branch of the learning sciences concerned with studying how people can learn together with the help of computers" (Stahl, Koschmann, & Suthers, 2006).

Computer supported collaborative work: “a generic term, which combines the understanding of the way people work in groups with the enabling technologies of computer networking, and associated hardware, software, services and techniques” (Wilson, 1991).

Constructivism: reality is constructed by the knower based upon mental activity (Jonassen, 1991).

Embodied interaction: “the creation, manipulation, and sharing of meaning through engaged interaction with artifacts“(Dourish, 2001).

Mixed Reality: "...anywhere between the extrema of the virtuality continuum." (Milgram & Kishimo, 1994).

Rich Media: Personal media that contains a large amount of information (Ngwenyama, & Lee, 1997).

Social Presence: “degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships” (Short, Wiliams, and Christie, 1978)

Telepresence: “an illusion that a mediated experience is not mediated” (Lombard and Ditton, 1997)

Virtual learning environment: a package to help lecturers create a course website with a minimum of technical skill, including tools for discussion and document sharing (Morgan, 2003).

Virtuality Continuum: The range between the completely virtual and the completely real (Milgram & Kishimo, 1994).

1.9. Summary

This chapter presented a brief overview of the problem of the lack of presence in online education and one possible technology, augmented reality, which may be useful in correcting it. The next chapter will delve into the literature and explore the theories and definitions that inform the current realm of thought on presence, collaboration, online learning, and augmented reality.

CHAPTER 2. LITERATURE REVIEW

As more students take advantage of the internet to learn, care must be taken to investigate new technologies that will support them in their endeavors. The following is a review of relevant literature on constructing educational augmented reality technologies. These technologies have the potential to help students collaborate with 3D models. Most of the literature is drawn from the fields of computer-supported collaborative work-learning, with recent additions addressing the potential benefit augmented reality has to bring to collaboration and education.

2.1. Distance Education

An increased demand for distance education has underscored a need for supplementary assistance in the form of online instruction. During the 2006 to 2007 school year, 65% of postsecondary institutions within the United States offered online courses for credit (Parsad & Lewis, 2008). Additionally, 3.5 million students enrolled in online courses in 2006, which was a 10 percent increase from 2005 (Allen & Seaman, 2007). Currently, many of the communication systems that students use are not specifically designed for class discussion and instruction. More often than not, this includes software designed for commercial and office use. The disparity between systems meant for work and those intended for instruction can significantly reduce the efficiency of the learning process (Ahern, Thomas, Tallent-Runnels, Lan, Cooper, Lu, & Cyrus, 2006). With such a large amount of students enrolled in distance education classes using these systems, there is a significant rationale for creating new systems that are specifically targeted at teaching and learning online. Even with a lack of digital communication systems specifically designed for learning, numerous technologies are available for use in distance education. The most common form of such technology is called a “learning content management system”, a “virtual learning environment”, a “learning management system”, or a “course management system”. A virtual learning environment (VLE) is a package of technologies focused on disseminating information to students and aiding the instructor in communicating with the students via grade books, message boards, and online chat. Well-known course management systems include *BlackboardVista*, *Moodle,* and *Sakai* (the last two being open-source technologies that allow schools to customize the technology as they see fit). Other programs may also be used in combination with these virtual learning environments.

In addition to distance learning programs, some educators use other types of educational software to help students learn and practice various tasks. For instance, astronomy classes may use a virtual planetarium or a physics class may make use of an online interactive homework system to provide immediate feedback to students. These types of systems could fall under the blossoming area of educational games. Such systems are meant to help students learn, but they are not meant to aid in the corollary parts of instruction such as administrative duties and communication between users. To aid in communication, VLEs will often include a text-based chat or forum feature.

The richness of the communication between users of virtual learning environments suffers because VLEs are primarily text-based web sites. The reliance on text makes VLEs different than a traditional classroom, which has the advantage of using face-to-face interaction to support any text used. To allow educators to approximate this element of classroom interaction, distance education is often supported by lectures that are recorded into a digital video format and later disseminated through a VLE for student viewing. A complex recording setup has previously been required for maintaining and controlling the lecture recording equipment, but recent technologies such as *Apresso Classroom* are making it easier to record and store the lectures institution-wide. These videos can be stored and re-used as needed, but they may not create a sense of instructor presence.

If a student taking a distance course desires to make direct contact with other class participants in real time, apart from making the trip to physically meet, video streaming services or online meeting systems may be used. Commonly used video chat programs are *Skype*, *AIM*, and *ooVoo*. These video chat services are used in combination with a web cam and microphone. Skype is the most common application, perhaps due to its penetration as a standard voice-over-IP (VOIP) software solution. (Pash, 2008). Web conferencing systems place these live streams into a system that allows for other types of communication, such as text chat, presentations, screen sharing, and digital whiteboards. There are a number of web conferencing systems. Some better known ones are *Adobe Connect*, *Microsoft Office Live Meeting*, and *CiTrix GoToMeeting*. These conferencing systems are the underpinnings of computer supported collaboration.

2.2. Computer supported collaborative learning

Computer-Supported Collaborative Learning (CSCL) is an approach to education combining constructivist theory, multiple learners, and computers. CSCL was first used as a term to describe a particular type of teaching in 1989 at a conference in Maratea, Italy (Stahl, Koschmann, & Suthers, 2006). During the 1980s CSCL research was founded primarily on constructivist theory during the teaching of the Logo programming language to students (Stahl, Koschmann, & Suthers, 2006). CSCL is based on constructivist theory. Constructivism is a theory that knowledge is constructed by the learner instead of being transferred from teacher to student (Ertmer & Newby, 1993). Constructivism also theorizes that the construction of knowledge is socially situated, or that learner’s creation of internal knowledge is influenced by their interaction with other people and ideas (Vygotsky, 1978; Bruner, 1990). Computers can play an important role in constructivist-based education. First, by giving students access to a large amount of information, learners are able to construct their knowledge of a subject by consulting a number of different sources on a subject. The socially-situated nature of constructivist learning, one that suggests students cannot form a piece of knowledge without interacting with another's viewpoint, also stresses the importance of using computers to connect two individuals in an act of collaborative learning. With or without a collaborator, the learning technology employed must lead to *contingencies*, or a concept that challenges a learner's current views of a concept and forces them to construct a new meaning for themselves that integrates the contingency they are dealing with into their body of knowledge about the subject.

CSCL has shown some promise for motivating students to learn. In Finland a CSCL curriculum was tested in their secondary education system (Lipponen, 1999). The curriculum combined exercises and the CSILE collaboration environment. The CSILE environment, similar to today's wikis, allowed students to create nodes of content, and collaboratively edit and link the content within those nodes. The CSCL system was tested without guidance or training on the computer technologies. The educators produced learning tasks for their students that were not well-defined, and were unable to help when questions arose. By the end of the first year, the students had started to act in self-regulating ways and took initiative to define and complete their assignments. The student independence came with a tradeoff: the students would 'collaborate' by asking each other factual questions ("What is the answer to…"), and stayed away from deeply understanding the concepts. The researchers noted a distinct gender difference in the adoption of CSCL; boys tended to take a major part in the collaborative activities. There were great benefits for the boys who were very passive in the traditional classroom; during the CSCL segments these males were some of the most active and productive in their classes. Lipponen concludes by warning that while their particular implementation of CSCL was very good at bringing out first-order (basic) learning effects in the students, the CSCL system studied in Finland was not able to produce second-order (deep understanding) effects, resulting in a system that did not have the intended benefits of CSCL: the deep understanding of material built by collaborative learning.

What the Finnish study may have lacked that is necessary for effective CSCL is genuine interdependence (Fjuk, & Krange, 1999). Genuine interdependence is the sharing of information, joint thinking, and a division of labor during collaboration. Fjuk and Krange recommend CSCL programs to assign tasks over time to achieve genuine interdependence by forcing students to collaborate efficiently. Limiting the time in such a manner requires that the software used should be as efficient as possible to allow for the best possible collective and educational interaction. A critical component of an efficient collaborative technology is up-to-date workspace awareness. Finally, the researchers state that a balance of distance and closeness to peers is the preferred way to implement CSCL. Distance in this context refers to time when users are not aware of, or directly interacting with, other users. When "distant," students spend time working on personal assignments and thinking introspectively. When “close,” students interact with the other users and encounter new ideas they may integrate into acquired knowledge.

While distance is essential for personal tasks and reflection, collaborative learning technologies require that students interact with each other. Collaborative interaction requires some shared space to provide students a way to communicate with each other. To create this shared space, distance educators often employ technologies such as wikis or interactive whiteboards that allow multiple uses to contribute simultaneously. When distance learners wish to interact with and discuss complex digital data at the same time, collaboration becomes more complex.

2.3. Computer supported collaborative work

Fortunately, the field of computer-supported collaborative work (CSCW) provides potential insight into how to create effective distance collaboration software. The field of CSCW seeks innovation in computer systems built to aid in distance collaboration. They often combine the physical and the digital into a mixed-reality space. A good example of the mixed-reality CSCW system was a digital presentation space designed to allow engineers to meet from a distance (Regenbrecht, Lum, Kohler, Ott, Wagner, Wilke, & Mueller, 2004). Regenbrecht constructed a space that placed web camera video onto 2D planes inside a 3D space. The system tracked gaze and tilted a 2D plane as a user moved their eyes to indicate what they were currently looking at. These tilted planes allowed for users to know who was talking to them directly. During the meeting engineering models and PowerPoint presentations could be displayed in a common area. The system had very limited interaction between users and virtual data beyond displaying and discussing information.

Previous research has indicated that the mode of communication has an effect on cooperation and perception of collaborators. In 2000, Jensen, Farnham, Drucker, and Kollack investigated the effects of communication modalities on cooperation by varying the mode of communication between collaborative tasks. Four modes of communication were used: no communication, text only, text-to-speech (translating typed text into sound via computer synthesized speech), and live audio. The subjects were asked to play a game of Prisoner’s Dilemma. In the game, victory is gained by having the most ‘points’ at the end of a round. The most effective way to get the most points is to trust and collaborate with the other players. However, players may renege on promises, giving them the advantage for the round. Depending on the players, this facet of the game may lead to an atmosphere of distrust. The researchers found that the players had higher opinions of their fellow players and gained more total points as the communication mode moved up from no communication to full speech. The players reported that the higher opinions resulted from a sense that the other player was more intelligent, likeable, and cooperative than in the lower modalities.

The effects of communication modality shares elements with the theory of social presence. Social presence can be loosely defined as the feeling that an individual is interacting with the user when they are actually quite far away. In 2001, Bradner and Mark investigated the effects of application sharing (two users viewing and interacting with the same screen from remote locations) on perceived social presence. By digitally observing users completing simple math problems via video chat or application sharing, the researchers were able to discern that perceived social presence is approximately the same in both contexts. When subjects perceived this social presence their performance suffered during the pre-collaborative (planning to speak) phase, possibly because they felt they had to 'perform' for those who were watching them. Bradner and Mark recommended giving users the option to suspend and resume when collaborative contact is needed.

A possible component of social presence is the richness of the communication mode used. Researchers in CSCL have been investigating the utility of rich video conference applications starting with the ground-breaking work of Chapanis in the 1970's. Chapanis conducted a series of studies to measure the effects of video sharing on distance communication, with an emphasis on the ability of video to convey nonverbal gestures known as cognitive cues (Chapanis, Ochsman, Parrish, & Weeks, 1972). During the original study, the video focused on the face and torso of the distant collaborator. Chapanis then compared the efficiency of the video and audio-only communication. The author's results indicated that video did not serve as an effective method for transferring cognitive cues; in many cases, the video channel performed only equally as well as the audio-only communication mode.

Video does have some traits that allow it to serve as a preferred communication channel. In 1995, Steve Whittaker observed that while face-to-face video of another person during communication was not effective for cognitive (turn-taking) cues, it was able to pass on affective (or emotional) cues to other users. Whittaker also suggested another use of video, a concept he termed "video-as-data". Video-as-data was live video sent to others to create a "shared physical context", or a video image that all parties could assume to be the same. Whittaker described four uses for video-as-data: coordination, disambiguation, physical embodiment of progress, and education. In a neurosurgery context, coordination was defined as the ability for the video to allow the nurse to anticipate the surgeon’s next need by looking at the current status of the operation. Disambiguation would allow the video to be broadcast to consultants in other areas for real-time input. Physical embodiment allows for distant operators who may be needed later to know where the operation is at and approximately how soon they will be needed. Finally, education allows for academics and trainees to view and learn from the surgery from outside the operating theater.

Much of the research on the utility of video now focuses on the concept of video-as-data, specifically the shared environment it can create. In recent years, the most common situational study would use live video in a “worker-helper” setup. The worker would be physically present with some object that needed to be manipulated while the helper was a remote expert who has a live video of the worker’s environment and the ability to talk with the worker. Case-studies highlighted in the literature include an anesthesiologist watching a live surgery (Nardi, Kuchinsky, Whittaker, Leichner, & Schwartz, 1995) and a master mechanic advising a novice on site (Fussel, Kraut, & Siegel, 2000). Kraut, Gergle, and Fussel have conducted a series of studies into the important properties of a shared visual space, and how it influences collaboration, though the use of a digital application that mimics screen-sharing technology. Their application recreated the worker-and-expert setup by sharing a puzzle screen between two users and allowed only the ‘worker’ to manipulate the pieces. The 'expert' user was provided a picture of the finished puzzle and had to guide the worker to finishing the puzzle. The authors found that a shared visual space reduced the number of words employed by the worker, and decreased the total task time (Kraut, Gergle, & Fussel, 2002).

Kraut et al. also examined the ability of shared visual space to ground the conversation. The theory of grounding, proposed by Clark and Brennan in 1991, describes the process of reaching “common ground” (what a speaker can assume everyone knows) during communication. For instance, certain cultural ideas such as country colors or name brands, can be considered “grounded” and require no explanation when used. The process of grounding happens continuously and eventually leads to more efficient communication. The space around speakers can be assumed to already be common ground, and quickly grounded during conversation. Through the use of deictic expressions ('this one', 'that', 'there') and confirmatory messages ('I get it', 'ok') two speakers can quickly confirm they are speaking about and manipulating the correct items without an extraneous amount of speech. Shared video can mimic real space and allow for similar common ground. During a series of tests with their puzzle application, Kraut, Gergle, and Fussel found more deictic phrases and less confirmatory messages were used when a shared video of the puzzle was present. The researchers speculated this was due to the common ground the video created between the two collaborators (Kraut, Gergle, & Fussel, 2002).

In addition to video creating shared space, it also can be used as a medium for physical actions to replace spoken language, potentially leading to more effective and natural communication. Kraut et al. observed sessions of their puzzle tasks for instances where actions were used as a method of communication. The researchers found that if workers made the correct action (such as placing the right puzzle piece in the right area) the expert moved on to the next set of instructions, reducing the need of confirmatory speech. The researchers concluded that because the other user can view their actions, one's actions spoke for themselves. With this, shared space dialogue is only needed to present new instructions, clarify unclear instructions, or correct an improper action (Kraut, Gergle, & Fussel, 2004).

In addition to removing the need for confirmatory messages, actions can be used to communicate. To examine the ability for gestures to communicate over distance Kirk, Rodden, and Fraser (2007) introduced hand gestures into a worker-and-expert situation. During the study, the researchers projected the expert's hands onto the worker's table, enabling the expert to indicate items and communicate motion through moving their hands. The expert and worker were placed at separate desks within the same room and an image of the other desk was projected onto their own. The subjects were then asked to build a specific *Lego* model. During the task the worker had the *Lego* pieces and the expert had the assembly instructions. Two trials were run, one with projected hands, and one without. When gestures were projected on the worker's desk, the two collaborators were able to complete the task more efficiently and with less speech. The researchers observed that when the projected hands were not present, the subjects had a tendency to speak at the same time. The researchers proposed that the presence of the projected hands may create some amount of social presence, allowing for cognitive cues to guide the flow of communication. It should be noted that in this study both users were present in the room at the same time, which could have contributed to the sense of the other person "being there." Another important point to note was that collaborators became faster at completing the task the more they became familiar with it, eventually making the projected gestures unnecessary. The researchers assumed that the conversation was becoming grounded by virtue of the subject's acquired expertise with the task. Kirk et al. state that gestures may only be useful for the start of a collaborative project or whenever a task is not routinely performed.

Recently, focus has shifted from investigating the effect of video on collaborative processes to modeling the factors that lead to grounding between two people. The eventual goal of this line of research is to construct a computational model that will allow a computer to analyze whether a human understands the system and provide more or less information based on the cues given. Shared visual space, and the grounding it provides, is an important factor in the creation of the computer models.

Consider a user who refers to an object nearby in the physical world. If he says "It's by that one," the computer would not necessarily know what "that one" means. If the computer has access to the current visual space, as well as a visual memory, the chances for the computer to determine what the user was talking about increases significantly compared to a speech-only computation (Gergle, Rose, & Kraut, 2007).

2.4. Augmented Reality

Augmented Reality (AR) has the potential to bring the benefits of a shared space, face-to-face interaction, and digital data together. The term augmented reality is best understood in the Milgram-Kashino mixed reality framework. On one side is augmented virtuality, which is predominately digital data and small amounts of the real environment. The other side is augmented reality, which is a combination of the real environment and a small amount of virtual data (Milgram and Kishino 1994; Milgram, Takemura et al. 1994). Typically the 'real environment' is presented to a user as video on a device. A common use for AR is overlaying data spatially in the video. The tracking for placement of the 3D data into the video stream can be done a number of ways, but one of the more common techniques is the use of 'fiducials'.

Figure 2.1 Milgram-Kashino Mixed-reality continuum.

Fiducials are printed markers that allow a computer to quickly process the rotation and distance of 2D plane in the video, and place digital data on top of that plane. This type of marker identification is implemented by default in *ARtoolkit*, and similar toolkits (*Studierstube, Reactivsion*). Augmented reality can be displayed either on a computer screen, on a Head Mounted Display (HMD), or on a mobile device. Screen-based AR presents the video data on a computer monitor and often is setup like a “mirror” that reflects the world in front of the screen with augmented data overlaid on top. An HMD is a set of goggles or glasses that display the world at approximately where the user's eyes are, plus the virtual data, on screens inside the HMD. This allows the user to move freely about, and experience a true ‘augmented reality’. Mobile devices such as smartphones combining the screen display, but show the world behind the device instead of in front.

Augmented reality in Adobe Flash has received a lot of attention now that FLARtoolkit has been out for over a year. Tools have appeared that allow for developers to use FLARtoolkit faster and easier (most notably FLARmanager and ARtisan).The basic ability to do fiducial tracking has been available to Flash in the form of *Reactivision* and the TUIO interface for a number years. The major problem with fiducial tracking in *Reactivision* was that it was limited to 2 dimensional (x and y) tracking. A number of very interesting demos have been created using *Reactivsion* and Flash by developers who are very interested in the area of tangible computing. Users are now beginning to explore the possibilities of FLARtoolkit beyond simple tech demos. Some of the notable early uses of FLARtoolkit are the GE Smartgrid demo, a number of AR business cards, and an AR game titled RubberDuckzilla. Recently, Peter Kaptein mocked up an interface similar to the one found in "Minority Report" using two fiducials to input data and gestures. This interface has been claimed by some as the arrival of developers who are beginning to use FLAR for more than novelty's sake. Prior to FLARtoolkit, academics and companies developed augmented reality applications with Artoolkit, NYARtoolkit, or studierstube. Some notable applications include Construct3D, human pac-man, wikitude, and Eye of Judgement.

One uncommon way to present augmented reality data is through streamed video. In 2004 Barakonyi, Fahmy, and Schmalsteig created an augmented reality chat system, resulting in each user seeing both their partner and digital data that their partner could manipulate. To create a reliable system, several technical factors were considered before completing the project. The most important factor was the ability of the computer to recognize the fiducials on compressed video. After a series of tests, the researchers determined that a computer could recognize fiducials on the compressed video almost as well as the uncompressed video. This rule holds true only when the fiducials being placed a short distance from the camera. Compared to uncompressed video, the computer recognition degrades quickly for compressed video. As such, there was no need to pre-compute any data before sending the compressed video to the other user's computer for processing and overlaying the 3D objects. After determining the acceptability of the compressed video, the researchers created a 3D volumetric application for their chat system, and ran some preliminary tests with potential users. For their augmented reality videochat system to work efficiently, a sufficiently large and well-lit space was required to display both the person and fiducial. Additionally, their AR chat system was inefficient for shared applications due to the lag of video transfer. They attempted to create a user interface for the system by 'floating' items in the video (placing them on top of the video data, like sticking decal on a window in front of the video), but it was too distracting to be useful. After presenting their application to a small sample of potential users, the researchers received positive feedback about the intuitiveness and potential usefulness of the application.

The speculated potential for augmented reality systems in aiding computer supported collaboration stems from the idea of a “mixed reality” which refers to the technique of combining physical and digital data in a form that feels “real” (Milgram & Kishino, 1994). One good example is the concept of tangible bits, which is described as technology that, "allows users to ‘grasp & manipulate' bits in the center of users' attention by coupling the bits with everyday physical objects and architectural surfaces" (Ishii & Ullmer, 1997).

While describing tangible bits, Ishii and Ullmer envisioned a new type of computer with the standard UI of computer screen, icons, and desktop replaced with physical items such as trays and instruments. Physical interaction with these devices would achieve the same results as a standard computer UI, but in more intuitive and distinctly physical way (Ishii & Ullmer, 1997). Ishi/Ulmer provide one example that demonstrates how a tangible user interface (TUI) could be achieved through the use of panes of glass as mobile screens, small objects as stand-ins for files, and a room where the background noise is information about coworker actions. These types of interactions are described by Paul Dourish as "embodied interaction". Embodied interaction is a way of thinking about and creating the digital world in the way that humans evolved to interact with the physical world (Dourish, 2001).

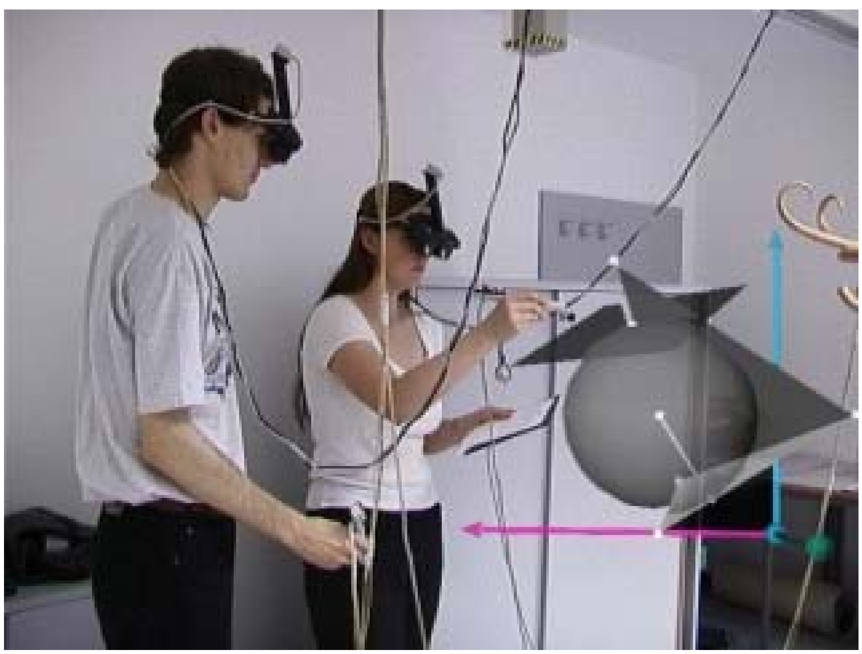


Figure 2.2 Construct3D: AR geometry education.

Coupling the digital and physical world has resulted in some useful learning technology. One example is *Construct3D*, an AR spatial ability training tool shown in Figure 2.2 (Kauffman, Steinbugl, Dunser, & Gluk, 2003). The program mimicked many of the major functions of a 3D modeling package, but was built only as a geometry education tool. In other words, there was no output for the software. *Construct3D* allowed multiple users to interact with the program in the same room by giving each user a HMD and their own interaction device, called a PIP (personal interaction panel). The PIP displayed data and allowed users to manipulate 3D objects using a pen, much like tablet PCs that are currently on the market. Informal usability tests, based on an ISONORM usability questionnaire, were run on *Construct3D* and users found it quite “easy to use” and “well suited to the task”. The researchers found that for collaboration, augmented reality provided a much more natural interface compared to standard CAD-based workspaces.

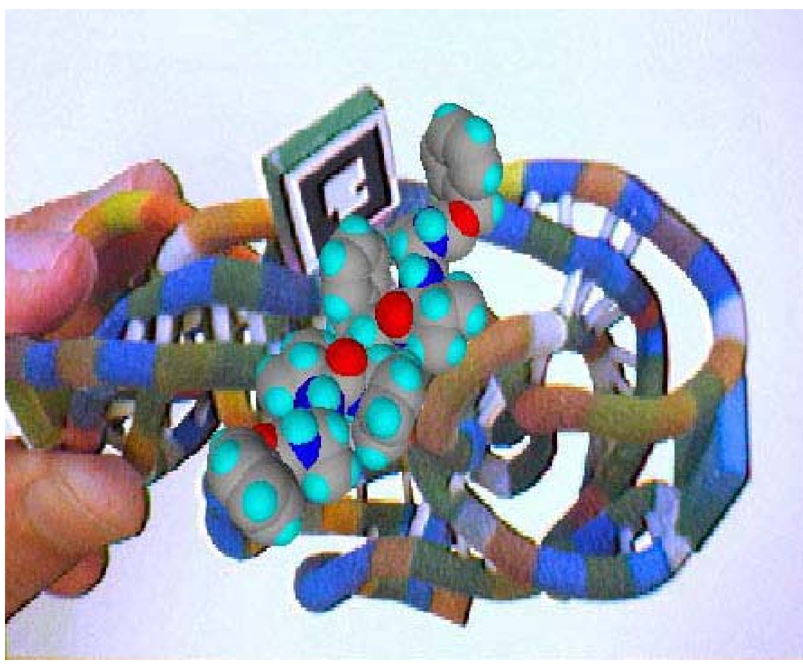


Figure 2.3 Augmented molecule.

In addition to geometry, augmented reality has shown some promise in chemistry education. Through interaction with four chemistry students using a screen based AR system that displayed interactive 3D molecular models, Chen (2006) found that an augmented-reality model can be nearly as useful for chemistry education as a standard physical model. The major item that the four students lacked was the physical feedback from the physical models. This was a tradeoff, as AR has the benefits of interactivity and animation. The interaction that was programmed for this study of AR models was a bit limited and buggy, leading to insights into frustration points that should be addressed when programming AR model manipulation. The most important of these was allowing 360 degrees of rotation in all three axes.

The study by Chen implies that the sense of touch, sometimes called haptics, may be an important sense that is lacking in augmented reality. An interesting approach to addressing this problem is to attach fiducials to physical models as shown in Figure 2.3 (Gillet, Sanner, Stoffler, Goodsell, & Olson, 2004). To test this approach, the researchers used auto-fabrication (3D-printing) devices to make molecular models from their digital counterparts, and attached fiducials to important areas of the model where digital data was desired. Potential points for fiducials identified by Gillet et al. were: parts of a molecule that could have different configurations, places where animation could be used to communicate, or parts where interaction is desired beyond what a physical model can provide. The researchers developed an augmented reality module to their molecular modeling software, called PVM. During testing the first prototypes the model would often obscure the fiducial, resulting in a loss of the digital overlay on the computer screen. One solution that worked well was simply attaching several fiducials to the model so that one would always be visible to the computer's camera.

Augmented reality has also been used with some success in physics education. Traditional physics lessons were recreated with digital models by adding a software physics engine to the same framework used by *Construct3D*, (Kaufmann & Meyer, 2008). The system (shown in Figure 2.4) was called *PhysicsPlayground,* and allowed students to replace physical experiments with similar digital experiments.

Figure 2.4 Physics Playground.

In an original version of a force-counterforce experiment, two students would stand on wagons, and each would hold one end of a rope. The first student would pull on the rope, then the second student, and finally both would pull on the rope. Regardless of who was pulling, both wagons would move the same distance. *PhysicsPlaygound* allowed the students to recreate the experiment by creating simple digital models, and applying forces to the models. The researchers mentioned that an advantage of using augmented reality to run a physics experiment was the ability to display accurate, real-time graphs of variables of interest.

2.5. Effectiveness

There are several barriers that limit the utility of both video chat and augmented reality for collaboration. The majority of these barriers were identified in the 1990's while many collaborative virtual environments (CVE) were built and tested. “Beyond Being There” was a keystone paper that helped to define future work in the area of CVEs (Hollan & Stornetta, 1992). In the paper, the authors pointed out that any attempt at digitally recreating face-to-face interaction would never fully recreate the real experience of being present with another. Instead of recreating face-to-face interaction, Hollan and Stornetta proposed that a digital communication medium should utilize its inherent strengths such as asynchronicity and automatic backup. The reason real face-to-face interaction may never be recreated digitally is that users of computer systems must keep two different egocenters (senses of where they are), one for the digital space, and the other for their physical space (Raskar, Welch, Cutts, Lake, Stesin, & Fuchs, 1998).

A study in 2006 reinforced the preference of real life interaction over virtual environments (Haubr, Regenbrecht, Billinghurst, & Cockburn, 2006). The researchers created four collaborative setups using a standard computer monitor and a touch-sensitive table display and asked the subjects to match pictures of dogs with their owners. The four collaborative setups created were face-to-face, spatial-local, spatial-remote, and 2D videoconferencing. Face-to-face was an actual physical meeting between users; spatial-local was a full-screen image of their collaborator and the pictures on the table display; 2D videoconferencing displayed a videoconference application and a 2D photo sharing application on a computer monitor; finally, spatial-remote displayed the collaborator's video within a virtual environment, and placed the pictures on a virtual model of a table between each user. After matching all the images to their potential owners, the subjects filled out a questionnaire about the perceived presence of the other user provided by each setup. The subjects answered questions about preference, copresense (the sense of the other being there), and social presence (a feeling of connection to the other user). In all the rankings, face-to-face interaction was significantly higher than the other setups. The spatial-local, 2D videoconferencing, and spatial-remote were not significantly different from each other, although there was a slight preference for 2D videoconferencing over other technologies.

In addition to the problems of recreating in-person meetings, augmented reality creates a number of difficulties in referencing digital items during conversation. Augmented reality systems either place data via a Cartesian coordinate system (sometimes aided by GPS data), or via fiducials within a video (Liarokapis & Newman, 2007). When using Cartesian coordinates and HMDs, the digital data appears over other users present, obscuring some gestures, and potentially changing the cohesiveness of the space (Fjeld, 2004). The opposite occurs when using video tracking. When a physical object obscures the fiducial in the video, the augmented data is lost until the tracked marker is unconcealed and recognized again by the computer. In addition, most augmented reality is presented with a single video feed. The lack of stereoscopy (presenting a slightly different image to each eye) makes it difficult to perceive the depth of objects due to the missing image parallax. One solution to the referencing problems is providing multiple and redundant forms of referencing an item, such as through speech, pointing, and digitally highlighting the object in question (Chastine & Zhu, 2008).

2.6. <u>Social presence in online education</u>

Gunawardena observed in 1995 that even with two-way video and high-fidelity audio connections, interaction patterns differed from typical face-to-face interactions. The study of how close a medium is to face-to-face interaction can be termed social presence. The concept of social presence was first defined in 1976 by Short, Williams, and Christie as the “degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships." They worked off of two areas of research to inform their theory of social presence: Argyle and Dean's concept of intimacy and Wiener and Mehrabian's ideas of interaction. These two concepts were major areas of research from psychology and communication (Lowenthal, 2009). According to Argyle and Dean, intimacy is communicated through social cues such as gaze and proximity. Indications of intimacy online and offline are provided through social norms and needs for affiliation (Gunawardena, 1995). Short et al. theorized that a lack of expected visual cues may cause distance communicators to overcompensate with stronger actions in the remaining modes of communication, such as extra words spoken over the phone. The second theory that informed the concept of social presence was immediacy, which is the psychological distance a person puts between themselves and what they are communicating with. This can be communicated through the body and language. One could speak either in a disinterested way or in a friendly and close way in order to change the amount of immediacy in their communication.

Short et al. were not the only researchers interested in the concept of distance communication at the time. Four years after they coined the term social presence, Minsky coined another: telepresence, which is the feeling that someone else is actually in the same physical space even though they are actually a far distance. One way to envision telepresence is to imagine 3D, full-body hologram (like the ones in the Star Wars movies) used to communicate from a distance. There are numerous other terms that deal with the sense of something being present when they actually are distant.

Social presence and telepresence are just a few of the terms that are used to speak about this concept of presence. Although defined first by Short, Williams, and Christie, later researchers defined and named social presence in differing ways. In 2007, as they attempted to compile a definitive list of telepresence literature, Lombard and Jones noted that there existed a number of terms and definitions for social presence. They reasoned this was primarily due to the interdisciplinary nature of the research that spanned departments as different as engineering and art. Some of the alternative definitions for social presence they identified were "being there," “the actual or perceived physical presence of objects and entities,” and “the psychological state or subjective perception in which a person fails to accurately and completely acknowledge the role of technology in an experience.” They also noted some other terms used that were synonymous or extremely similar to telepresence: social presence, virtual presence, presence, parasocial, perceived reality, and computers as social actors. All of these terms were defined and used by a research group known as the International Society for Presence Research.

In the year 2000 the International Society for Presence Research attempted to define presence, and the many subsections of presence of which social presence is just one. They stated that the feeling of presence, “occurs when part or all of a person's perception fails to accurately acknowledge the role of technology that makes it appear that s/he is communicating with one or more other people or entities." This sense of presence can vary such that a person can feel more or less “present,” and may even experience different amounts of presence using the same technology at different times. They defined the sub-components of presence in a similar way to the overarching concept of presence. For example, they stated that social presence, “occurs when part or all of a person's perception fails to accurately acknowledge the role of technology that makes it appear that s/he is communicating with one or more other people or entities.“ Some of the other components of presence related to social presence were co-presence (the feeling of being in the same room as the other), parasocial interaction (a feeling of two-way communication when in fact only the media is communicating), and medium as social actor (a failure to realize one is interacting with technology at all). Of these three, co-presence has been suggested to have a potential influence on the perception of social presence.

Social presence has been suggested as a key ingredient in online education. Another way of thinking about social presence is through the term “psychological distance”. It is a way of talking about and measuring how far away the other user feels, regardless of their actual distance. With less psychological distance between learners and other class participants (both other learners and instructors) comes an increased amount of course satisfaction and personal connection between users (So & Brush, 2007). The increased personal connection is important because it allows the users to view the others as “real people” that they can communicate with in typical ways (Shea & Bidjerano, 2008). In other words, viewing others as a real person breaks some of the formalism that is imposed on asynchronous text communication (So & Brush, 2007).

Real people have the ability to become close to users and teach them more effectively because of their closeness. In the words of Wiener and Mehrabian, real instructors can become more immediate to the learners. They defined a construct of immediacy that measured the psychological distance between instructor and student (Wiener & Mehrabian, 1968). The more immediate the teacher is, the more motivated students may be to study, and the more satisfied they may be with the course (Christophel & Gorham, 1995; Moore, Masterson, Christophel, & Shea, 1996). Perhaps due to these benefits, students also report a higher sense of learning from courses with higher levels of social presence (Richardson & Swan, 2003). Connection between the learner and the instructor is important, both online and offline.

Connection between students can be equally important for student success and satisfaction. Students are more satisfied when interacting with other students versus instructors (Jung, Choi, Lim, & Leeem, 2002). Conversely, a lack of interpersonal connection to other students is often associated with stressed and isolated students (Haythornthwaite, Kazmer, Robbins and Shoemaker, 2000). Instead of isolated students, it is better to create a sense of community among students so that they may be mutually interdependent and share the same goals (Rovai, 2002). The students who participated the most in the class community had a higher chance at receiving a good grade in a distance course (Davies & Graff, 2005). Increased social presence also leads to higher levels of perceived learning (Richardson & Swan, 2003). However, too much connection can lead to distraction from the course content, resulting in too much social interaction and not enough cognitive interaction (So & Brush, 2007).

Discourse is an important part of social learning (Lowenthal, 2009). Creating good discourse is hard without having some good social connections between the learners first. This social connection does not have to be created in rich media such as video, even text-based computer mediated communication will eventually lead to good social connections between the users (Gunawardena, 1995; Gunawardena, 1997). In order to get to this point of strong connections it is the task of the instructor to foster and sustain social presence during online instruction and to design the course to encourage social interaction (Anderson, Rourke, Garrison, & Archer, 2001; Gunawardena, 1997).

Measuring social presence is a difficult task due to its interdisciplinary nature. While a majority of researchers are content to use the original measurement instruments created by Short et al, a growing number are developing new instruments that measure factors related to their different definitions of social presence. Bioncca, Harms, and Burgoon identified at least 8 ways to measure social presence or closely related concepts that each focused on different aspects of presence (such as the medium, the social interaction, or the closeness of the communicators). Most of the tools developed to measure social presence are pencil-and-paper questionnaires that measured using the semantic differential technique (Osgood, Suci, et al, 1957). The questionnaire has sets of terms on the side of a Likert scale for participants to choose where the experience fell between. Some of the pairs of terms included by Short et al. were “cold-warm,” “impersonal-personal,” and “unsociable-sociable.”

Another difficulty with presence research and study is the ambiguity and complexity of the term. Bioncca, Harms, and Burgoon found fault with the state of presence research in 2003. They noted that it was difficult to draw comparisons across studies due to the differences in questionnaires, terms, and definitions. There were a number of different aspects that factored into different types of presence. The complexity of the term resulted in some researchers using the term in a very loose way such as “being there”.

Social presence in online education is most typically measured through the use of a specialized questionnaire developed by Gunawerda and Zitta which asses a number of items that appear to be related effective use of presence in online education. It is focused on the interactions between students, instructors, and course content. Gunawerda used this questionnaire in 1995 to asses a computer-mediated conference that involved several of his students. Since then aspects of the test have been used in large numbers of studies covering online learning (Lowenthal, 2009). Due to the aforementioned hazy nature of the term social presence, these questionnaires actually cover the sense of social presence, and some other related concepts such as instructor immediacy and cognitive presence.

2.7. Conclusion

Computer supported collaboration could potentially be aided by the addition of video. CSCL and CSCW are heavily dependent on interactions between users. Video is able to foster connections between users in a better way than text or audio. Additionally, collaborators who ascribe more human traits to their peers tend to produce groups that perform better. The video format is also useful for creating a shared space that collaborators can both reference during their working time. This shared space produces conversation that can quickly be grounded, leading to more efficient and effective communication. When given a choice, collaborators always express a preference for meeting in person. This may indicate that our most recent collaborative technology cannot create an acceptable amount of social presence for the users. It may also indicate that a user’s ego center is so grounded in the real world that it will be impossible to recreate a face to face meeting. A number of technologies attempt to create a sense of eye contact, one major facet missing in standard meeting systems.

Augmented reality has the ability to place digital models on top of real time video in a way that has the ability to replace the physical models, if necessary. By combining AR with a video chat application, it is possible that the users who both do not have the same model will be able to pull it out and reference it with an analogous fiducial and interact with that model in a way that they are used to interacting with other, physical objects. This is in addition to the other benefits that video chat already can supply by functioning as an ice-breaker (Tscholl, Mcarthy, & Scholl, 2006), providing for gestures, and allowing for cognitive cues during collaboration. The usefulness of an augmented chat system may only be for sporadic "bursts," as over time the video component may become unnecessary due to task and collaborator familiarity.

CHAPTER 3. METHODOLOGY

Combining augmented reality spaces with video conferencing could provide for increased perception of social presence and contribute to more efficient communication. To test the differences between these two collaborative softwares, an augmented reality video chat application was created using Adobe Flash and Red 5 Media Server that allowed for 2 users to collaborate on an open-ended grouping task, and compared to a combination of GoToMeeting and Google Sketchup, a web conferencing system and 3D sketching system typical of others in the market, for effectiveness in the terms of social presence and efficiency. These systems were selected primarily because of their popularity and high online user reviews for ease of use.

3.1. Hypotheses

This study examined whether a mixed-reality video chat system could be more effective for distance learning groups than a traditional web conferencing system. As defined in the literature review, two areas that are critical for creating effective distance collaborative groups are social presence and copresence. The hypothesis drawn from these three areas are:

$H1_0$: The augmented reality chat system and the representative traditional web conferencing system generate a similar degree of measured social presence.
$H1_a$: There is a significant difference in the measurement of social presence created by the two systems.

$H2_0$: The augmented reality chat system and the representative traditional web conferencing system generate a similar degree of measured copresence.
$H2_a$: There is a significant difference in the measurement of copresence created by the two systems.

3.2. Application Design

The augmented reality chat application shown in figure 3.1 was developed using *Adobe Flash* to handle the display of video and the overlay of augmented reality objects. The streaming of video and synchronizing of digital data between clients was handled by the open-source flash server, *Red5*. The *Red5* server was installed close to the testing area in order to ensure low video latency (the time between video being sent from one user, and received to the other) for the users. Red5 is a video streaming/multi-user server that is similar to Flash Media Server. The two systems are nearly identical for the purposes of this study as they are able to transfer audio and video at the same rates.

The open-source *FLARtoolkit Actionscript* library was used in conjunction with the *Flash* client to recognize the fiducials given to each user. Finally, the 3D model was rendered to each client's screen using *Papervision 2.0,* a 3D engine programmed in *Actionscript 3.0*. The Adobe Flash technology was chosen because of its large market penetration and the flexibility it provides in designing an intuitive interface (which is often a requirement of web conferencing systems). In addition, many collaborative spaces are web-based, where the Flash web plug-in penetration makes it a standard target for such rich media applications. Adobe Flash does not render 3D particularly fast, nor can it run efficient fiducial marker recognition due to the limitations of the ActionScript Virtual Machine that currently runs only on the CPU. However, performance on light 3D models of less than ten thousand polygons resulted in performance that was nearly equal to solutions implemented in C++ and OpenGL. To get the most performance out of the test Flash application, it was be run directly from the *Flash* player on the computer, removing any processing overhead associated with running *Flash* within a browser window. As future Flash players improve in performance this application could easily be moved to the web by uploading it to a webserver.

Figure 3.1 Example of the application.

3.3. Population

The students who benefit the most from collaborative learning are students who are most capable of collaborating within a constructivist learning environment. These students are usually at a postsecondary to professional level. As such, the population for this test was postsecondary education students between 18 – 50 years of age.

3.4. Sampling Size & Selection

48 students (24 pairs) were sampled. Students from the Computer Graphics Technology department at Purdue University were the primary sampling space. These students needed to be comfortable with the use of computers, familiar with the concepts of web conferencing systems (but haven't necessarily used them before), and familiar with 3D modeling packages. The sample was recruited from an email campaign, flyers posted about campus, and announcements made in undergraduate classes. Students were offered extra credit for participation.

3.5. Testing Procedure

Following a similar design to the dog-and-owner matching study (Haubr, Regenbrecht, Billinghurst, & Cockburn, 2006), the subjects brought a same-gender friend to act as their teammate for the study. Same-sex pairs were included to reduce any tensions that may arise from inter-gender interactions. The test moderator began by presenting a brief walkthrough of the study to the subjects, instructed both of them on the use of the software to be used during the study, and gave them each their own fiducials for the augmented reality conference (See appendix A). They were then taken to separate rooms and seated at computer workstations. Once in front of the computer, the researcher loaded either the augmented reality conference system, or *CiTrix GoToMeeting* along with *Google Sketchup*. To control for learning and fatigue effects, participants were randomly assigned to complete either the augmented or screen sharing task first.

The two then completed an object matching task in GoToMeeting and an object identification task within the augmented reality program, with a maximum of five minutes in each system (see appendix B). In the Haubr, Regenbrecht, Billinghurst, & Cockburn study users were asked to match dogs with owners, in order to encourage discussion and deliberation. The task was changed to take advantage of the 3D nature of augmented reality collaboration. In the augmented reality conference system, subjects were each given a fiducial that, when held to the camera, displayed an indistinct object they needed to indentify. There was no correct answer to the model question, and the participants took approximately the whole five minutes in discussion. Within Google Sketchup and GoToMeeting participants viewed a Sketchup file that contained 10 models within the 3D space to group (see appendix C). The models were different for the two systems. The shapes were different combinations of primitives and colors, such as a red cube and a green pyramid. The participants were instructed to ask for help if the technology malfunctioned. Once done, participants verbally signaled to the researcher that they had completed the task. The researcher then entered and set up the new task and told them they may start. After both tasks were completed (about ten minutes total), the researcher returned the participants to a single room, where they completed a two surveys (see appendices D and E) and were briefly interviewed.

3.6. Data Collection

Before the exercises, a questionnaire (see appendix F) was given to collect demographic information such as age, gender, and familiarity with the types of programs to be used during the test. After completing the two exercises, three surveys were given to the participants. The first two surveys were adapted from a similar study by Harbur, Regenbrecht, Billinghurst, and Cockburn. The first survey (see appendix D) covered aspects of copresence, and asks questions such as “It felt as if my partner and I were in the same room”. The second survey (see appendix E) on social presence was measured with a semantic differential technique defined by Short et al. This survey was measured on a seven point scale between pairs of words meant to define the technology. Some of the pairs were “formal – spontaneous” and “insensitive – sensitive”. Once these surveys were complete, the researcher conducted a short interview with the pair.

CHAPTER 4. RESULTS

After the data had been gathered, it was entered into *Microsoft Excel* for further analysis with *SAS* and *Minitab* in regards to copresence, social presence, and the systems as a whole. The data was analyzed with descriptive measures, factor analysis, paired-t tests, and power analysis.

4.1. Copresence measures

Tables 4.1 and 4.2 contain the descriptive statistics for the measured copresence of the two systems. The standard deviations were never greater than 2 for each system. Additionally, the means for the GoToMeeting system were generally higher than those for the augmented reality chat system.

Table 4.1 *Copresence measures for ARchat*

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
location	48	0	1.958	0.232	1.611	1.000	1.000	1.000	2.750
presence	48	0	1.813	0.194	1.347	1.000	1.000	1.000	2.000
face	48	0	3.146	0.253	1.750	1.000	2.000	3.000	4.750
same	48	0	3.854	0.270	1.868	1.000	2.250	3.500	6.000

Seeing that each pair answered nearly the same (the standard deviation was not above 2) the pair's responses were averaged together to create a new dataset of 24 samples. This was done to avoid artificially expanding the data. Using the original 48 samples would not violate any statistical rules, but averaging the data results in more accurate statistical interpretations. Using the new dataset, a two-factor analysis was performed to verify the battery of questions (see Appendix D) that targeted copresence were correlated and that they were not related to the measures of social presence. Table 4.3 shows the results of this two-factor analysis.

Table 4.2 *Copresence measures for GoToMeeting*

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
location	48	0	2.229	0.260	1.801	1.000	1.000	1.000	3.000
presence	48	0	2.229	0.229	1.588	1.000	1.000	2.000	3.000
face	48	0	4.149	0.249	1.706	1.000	3.000	4.000	6.000
same	48	0	4.271	0.261	1.807	1.000	3.000	4.000	6.000

Table 4.3 *Two factor analysis of copresence*

Question	Factor1	Factor2
Conference locations	-0.46863	0.52710
Conference presence	-0.47624	0.54314
Conference face	-0.78550	0.23197
Conference same	-0.68871	-0.20061
Augmented locations	-0.09158	0.68750
Augmented presence	0.07138	0.51942
Augmented face	-0.41806	-0.21074
Augmented same	-0.55796	-0.52729

In general, the measures are correlated for factor one, leading to the conclusion that the questions used to measure copresence measured a similar concept. In addition, these numbers are generally negatively correlated with the questions covering social presence, indicating that these two questionnaires measured different concepts. The two-factor analysis served one last purpose: to reduce a battery of questions to a single number that could be tested for each pair.

Table 4.4 *Paired T-test of copresence*

	N	Mean	StDev	SE Mean
Conference	12	0.037	1.288	0.372
Augmented	12	-0.037	0.655	0.189
Difference	12	0.074	1.491	0.0856

95% CI for mean difference: (-0.873, 1.021)

T-Test of mean difference = 0 (vs not = 0): T-Value = 0.17 P-Value = 0.867

After verifying that the concepts measured were distinct and reducing the measure of copresence to a single number, the researcher was ready to perform a test of significance. The researcher was only interested in differences between systems, not in one system being more highly rated. For this test, μ_1 represented the mean copresence factor scores for screen sharing and μ_2 represented the mean factor scores for ARchat. Therefore the null and alternative hypotheses were:

$$H_o : \mu_1 = \mu_2 \qquad H_a : \mu_1 \neq \mu_2$$

The t-test produced a value of .17 with 23 degrees of freedom, which yielded a P-value of .867; it failed to be significant at the .05 level. This indicates that there is no difference between the systems in terms of copresence.

4.2. Social presence

The same process applied to copresence measures was applied to the social presence measured. Tables 4.4 and 4.5 contain the descriptive statistics for the measured social presence of the two systems. The standard deviations were never greater than 2 for each system. Neither system appears to have an easily discernable difference in the means for the social presence measures. Because the pair’s responses were similar, the data for each pair was averaged together to create a new dataset of 24 samples.

Table 4.5 *Social presence measures for GoToMeeting*

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
impersonal	48	0	4.083	0.220	1.528	1.000	3.000	4.000	5.000
cold	48	0	3.937	0.209	1.450	1.000	3.000	4.000	5.000
ugly	48	0	3.771	0.179	1.242	1.000	3.000	4.000	4.000
small	48	0	4.063	0.213	1.479	1.000	3.000	4.000	5.000
insensitive	48	0	4.375	0.183	1.265	2.000	3.250	4.000	5.000
colorless	48	0	4.958	0.191	1.320	2.000	4.000	5.000	6.000
unsociable	48	0	4.896	0.221	1.533	2.000	4.000	5.000	6.000
closed	48	0	4.583	0.220	1.528	2.000	3.000	5.000	6.000
passive	48	0	5.042	0.244	1.688	1.000	4.000	5.000	6.000

Table 4.6 *Social presence measures for ARchat*

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
impersonal	48	0	5.229	0.231	1.601	1.000	5.000	6.000	6.000
cold	48	0	4.813	0.162	1.123	2.000	4.000	5.000	6.000
ugly	48	0	4.333	0.156	1.078	2.000	4.000	4.000	5.000
small	48	0	4.188	0.197	1.363	1.000	3.000	4.000	5.000
insensitive	48	0	4.792	0.186	1.288	1.000	4.000	5.000	6.000
colorless	48	0	4.917	0.176	1.217	2.000	4.000	5.000	6.000
unsociable	48	0	5.375	0.222	1.539	1.000	4.000	6.000	7.000
closed	48	0	5.083	0.216	1.499	1.000	4.000	5.000	6.000
passive	48	0	5.687	0.181	1.257	2.000	5.000	6.000	6.750

After averaging the paired data, a factor analysis was performed on the data to simplify the battery of questions relating to social presence and copresense to just two factors and verify they were measuring distinct properties. A factor analysis takes a battery of questions, and returns a single number for each question for a specified number of "factors". This number indicates how much that question influences the variance in that factor. This study was concerned with the concepts of presence and copresence, therefore a two-factor analysis was chosen. More factors could have been determined and examined if there had been no prior assumptions about the nature of the data. Table 4.6 contains the results of the factor analysis and the loadings of each question on two factors for social presence. The questions that measured presence generally load negatively on copresense, while those that targeted copresense were generally negative for presence. This implies that the two surveys were measuring two different variables.

Table 4.7 *Two-factor analysis of social presence*

Question	Factor1	Factor2
Conference imper	0.71326	-0.31258
Conference cold	0.55816	-0.53829
Conference ugly	0.58028	-0.22645
Conference small	0.41610	-0.09709
Conference insen	0.30636	-0.47543
Conference cololess	0.34564	0.27657
Conference unsociable	0.79420	-0.19308
Conference closed	0.70034	-0.06414
Conference passive	0.54256	-0.42689
Augmented imper	0.10483	0.39860
Augmented cold	0.39975	0.29074
Augmented ugly	0.60783	0.23643
Augmented small	0.71984	0.23108
Augmented insen	0.46702	0.30110
Augmented cololess	0.60451	0.32411
Augmented unsociable	0.44932	0.43010
Augmented closed	0.82431	0.34421

Using the scores of social presence (how much a sample influenced the factor analysis), a paired t-test was performed to determine if any of the differences between the two systems were significant at an alpha value of .05. For this test, μ_1 represented the mean social presence factor scores for screen sharing and μ_2 represented the mean factor scores for ARchat. Therefore the null and alternative hypotheses were:

$$H_o : \mu_1 = \mu_2 \qquad H_a : \mu_1 \neq \mu_2$$

Table 4.8 *Paired T-test of social presence*

	N	Mean	StDev	SE Mean
Conference	12	-0.068	1.074	0.310
Augmented	12	0.068	0.963	0.278
Difference	12	-0.135	1.523	0.440

95% CI for mean difference: (-1.103, .832)

T-Test of mean difference = 0 (vs not = 0): T-Value = -0.31 P-Value = 0.764

The t-test produced a value of -.31 with 23 degrees of freedom, which yielded a p-value of .764; it failed to be significant at the .05 level. This means that participants did not indicate a difference between either system in terms of social presence.

4.3. Difference in combined systems

The researcher then combined the totals for the social presence and copresence factors to determine if there was a difference between the systems that was not apparent from the copresence and social presence specific statistics. Table 4.7 contains the results of the test.

For this test the researcher was only interested in basic differences between the set of software packages. The μ_1 represented the mean factor scores for screen sharing and μ_2 represented the mean factor scores for ARchat. Therefore the null and alternative hypotheses were: Ho : μ1 = μ2 and Ha : μ1 ≠ μ2.

The t-test produced a value of -.23 with 23 degrees of freedom, which yielded a p-value of .826; it failed to be significant at the .05 level. This indicates that the users did not feel like there was a difference in total presence between the two systems.

Table 4.9 *Paired T-test of combined social presence and copresence*

	N	Mean	StDev	SE Mean
Conference	12	-0.052	1.142	0.372
Augmented	12	0.051	0.885	0.189
Difference	12	-0.103	1.577	0.455

95% CI for mean difference: (-1.105, .900)

T-Test of mean difference = 0 (vs not = 0): T-Value = -0.23 P-Value = 0.826

4.4. Power test

Finally, three power analyses were performed to determine the accuracy of the paired t-tests looking for significance at alpha of .05. The power for these paired t-tests all were approximately .05. A power of .05 is quite low, as the standard for acceptability in terms of power is .8 or above. These low values indicate that when looking for a difference of .05 on the paired-t tests, there is a high chance of accepting a null hypothesis when it should have been rejected. In order to discern differences at this significance level, approximately 200 more participants would be needed.

4.5. Summary

This chapter presented a summary of the data gathered and explained the statistical processes used to reach initial conclusions on the data. The original data was gathered over three weeks and had a total of 48 participants. After gathering descriptive statistics on the data, it was assumed that each pair's experience of the system was correlated. Their answers were averaged together, resulting in a new dataset of 24 samples. A factor analysis was performed on the data that seemed to indicate the presence of two distinct factors. Using the factor scores, three paired t-tests were performed for social presence, copresence, and total presence. For all three tests, the null hypotheses were not rejected, indicating a similar amount of presence in each system.

CHAPTER 5. CONCLUSIONS

The hypothesis that an augmented reality chat system would be able to create a higher sense of presence than a screen sharing application was rejected. Instead, both systems were rated as having similar amounts of perceived presence. Conclusions and recommendations are drawn below in regards to factors that may have influenced the sense of presence, educational implications, and possible future work.

5.1. Findings and discussion

The similar amounts of perceived presence may have been influenced by the sound communication medium. Both participants were using cell phones to communicate while using the software. While this is not an uncommon way to use web conferencing software, using speakers positioned around the computer may positively influence the perception of presence. It is hypothesized that sound may play a very important role in the perception of social presence from a distance. Chapanis (1972) confirmed the video was not able to enhance collaboration from a distance. However, during the prisoner's dilemma experiment, participants trusted and respected their fellow players more as communication mode approached full speech (Jensen, Farnham, Drucker, & Kollack, 2000). There remains a gap in the research that does not confirm if playing the same game with live video of each player influences the final result of the game. If it does not, audio may be a preferred distance collaboration tool. Designers of distance instruction recognize that to create good distance learning groups audio will be required. Technologies like VOIP or group calls should be used in order to establish higher senses of presence within the course.

A program chosen for a CSCL endeavor should be best suited to the task. When developing applications to be used for CSCL, care should be taken to emphasize using video as data (Whittaker, 1995), creating useful shared spaces, and focusing on the advantages that digital technology can provide over traditional interaction. If a course requires a combination of a human body and 3D data, then an AR chat could be a useful technology. However, if it just required the use of 3D data, a screen sharing application with an audio link would be the preferred way of completing the work.

Observing students who used the technology, it appeared they used the same amount of deictic phrases in both the augmented reality and the screen sharing applications. It also appeared they used a minimum of hand gestures while using the augmented reality system. This was primarily due to the positioning involved in using the application. In order to properly see the 3D model it was necessary for the fiducial to fill a large amount of the video, restricting the participant's access to the screen and not allowing them much room to point without obscuring the fiducial (which would result in the loss of the 3D augmentation).

It may be that both packages do not create a familiar type of shared space. While the augmented reality chat had the potential advantage of face-to-face communication, it required holding fiducials in an awkward position that occasionally obscured the user's face. These limitations were encountered previously by researchers testing their own augmented reality videochat (Barakonyi, Fahmy, & Schmalsteig, 2004). The screen sharing application allowed for a shared space that both users could manipulate, but they were unable to manipulate different objects at the same time, requiring users to take turns using the software. This turn taking setup often resulted in one person doing all the manipulation and judgments while the second user merely agreed upon the decisions made. The screen sharing application also took up a large amount of the computer screen, resulting in a minimized area for the collaborator's video with reduced capability to convey cognitive cues.

One unforeseen complication in the study was the type of interactions between participants that took place. Often the participants took up a "worker and expert" type of interaction with one user doing most the work, and the other advising (Kraut, Gergle, & Fussel, 2002). Occasionally one person did both the deciding and work, creating an "expert and manager" situation. It may be good to attempt to recreate the study in a real class that generates a sense of genuine interdependence (Fjuk, & Krange, 1999).

If the collaborator's video is assumed to not be "real life" data, then the augmented reality chat system as created may have fell closer to an augmented virtuality on the mixed reality continuum (Milgram & Kashino, 1994). If the ARchat application was more of an augmented virtuality, the previously described benefits of augmented realty would not necessary be applicable. This is not to say they do not transfer over, as many of the findings within the field of CSCL focused on augmented virtuality rather than augmented reality. However, any benefits and senses of presence gained from this system may have been of a qualitatively different nature than those found in the Studeirstube-based systems such as Construct3D and Physics Playground. Within those systems, the students were gathered in real life, instead of collaborating at a distance, potentially leading to drastically different interactions.

While the hope was the ability of an ARchat to create a system that allowed for tangible bits to be manipulated, it is possible that displaying 3D objects overlaid on top of a fiducial is not an accurate interpretation of a tangible bit. A paper fiducial is so distant from what is actually being displayed that the users do not use natural interactions that drive the theories behind tangible bits and embodied interaction (Ishii & Ulmer, 1997; Dourish, 2001). A similar result was found by Chen (2006) who noted that some students did not prefer augmented reality molecular models because they lacked the physicality of the physical models they were used to.

There may have been a reason that the Barakonyi, Fahmy, and Schmalsteig (2004) did not continue investigating the usefulness of an augmented reality chat. Although their testing and initial feedback indicated perceived usefulness for the application, the positions and conditions needed for a smoothly running ARchat were uncommon. The Studierstube project that their ARchat was built on top of was also responsible for other technologies, such as Construct3D and Physics Playground (Kaufmann & Meyer, 2008; Kauffman, Steinbugl, Dunser, & Gluk, 2003). It appears as if these applications of AR had a stronger perception of usefulness than distance collaboration using augmented reality.

The study conducted by Hauber et al. (2006) that was the template for this current study, had similar results. There was not a major difference between any distance collaboration system tested. Instead, there was a strong preference for meeting in person. Since the questionnaires for this study were the same as the one used by those researchers, the augmented reality chat may be a candidate to be added to the list of systems that are identical in terms of presence. A large amount of similarity in presence for distant systems points to the chance that distance collaboration does not change much once video and audio is introduced, no matter what setup they are placed in, including spatial-remote, spatial-local, 2D, and augmented modes.

The fact that social presence is affected by immediacy (Short, Christie, & Williams, 1972; Wiener & Mehrabian, 1968) may inform designers as to what types of technology to focus on when creating new applications for social presence and distance collaboration. Immediacy is affected by both language (types of responses) and body language (how the conversant is acting). It may be that the major hints we receive for immediacy are not so much from body language, but the actual verbalizations from the other speaker.

5.2. Recommendations

Ultimately the supposed utility of AR chat rested on the ability of video to convey cognitive cues resulting in users that felt closer together. The distance between users may be so great that it is impossible to recreate natural interaction. Instead, one may need to rely on audio communication and video solely as data. Knowing the difficulty of recreating presence, future developers may wish to focus on the best aspects of technology as described in "Beyond Being There" (Hollan & Stornetta, 1992). Two of these aspects were asynchronicity and the ability to store data for later use. Storing data from online interactions, especially in an educational area where these interactions could serve to inform other learners, is a key feature that should not be ignored by those creating new virtual learning environments.

Gestures, one of the primary communication advantages, were lost in both systems, resulting in the reduced advantages of increased deictic phrases and efficiency of communication (Kirk, Rodden, & Fraser, 2007). This lost advantage may have affected the sense of perceived presence when a participant was using the system. This also indicates that both systems may have been slower than they could have been in terms of efficiency of communication.

Both systems appeared to hinder the creation of common ground. The augmented reality system did not really create a shared space for the students to see in tandem, limiting their ability to assume that one knew what the other was seeing. In contrast, the shared space allowed both users to see the same thing, indicating they had some sense of shared space, but perhaps the oddity of what they were seeing was strange enough to them they could not quite identify what kind of space they shared at the time. The time it took to ground the conversation may have effectively negated the effects of a shared space on grounding the conversation, which resulted in a large number of non-deictic phrases used to specify what exactly there was on the screen at the time.

As this implementation of AR was not an incredibly successful example, one may wish to focus on augmented reality in its more typical manifestations, such as HMDs and mobile devices. Some of the more common uses of AR are on mobile devices and using it for games such as Human Pacman (Cheok et al., 2004). A focus on the capability of mobile devices to create engaging augmented reality experiences may lead to interesting insights as to how to apply those same principles to those who are interacting from a distance.

The systems may also serve as a novel way to introduce fun into collaboration, a subject that was outside of the scope of this investigation. As many of the users indicated they had fun with the systems during the post-task interview, these systems could aide in the introductory phase of collaboration by breaking down the formalism that is normally associated with text-based communication. More practically, this type of augmented reality chat may be best for an instructor who has prepared to use the chat to demonstrate different ideas without having different technology on hand, such as if they are away at a meeting, or not able to buy expensive demonstration models. One potential side effect of the fun that the systems create is that they could currently be too distracting. It may be some time before general users are accustomed to augmented reality and can look past it novelty to use it mainly as a tool for communication and collaboration. Until then, it may negatively affect the perception of presence by reducing the attention paid to one’s partner, resulting in less attention being paid to collaborators and a reduced amount of perceived closeness between users.

5.3. Future work

Augmented reality technology is quickly progressing as researchers and developers take an increased interest in its possibilities. Soon it will be possible to use hands as a replacement for the paper fiducials used in this study, allowing for the creation of very real “embodied interaction” (Dourish, 2001) with computer systems. Using hands as a marker does remove the advantages of having a tangible item to manipulate, that may detract from its eventual usefulness. It would be interesting to study if the loss of a tangible interface results in a system that is more agreeable for interaction between two users on a video chat system.

Due to time limitations, it was not possible to directly measure deictic phrases or gestures during the study. Thus, it is not known if the augmented reality system was able to create more efficient conversation, nor is it known if users overcompensated for the lack of visual cues when working inside of the screen sharing application (Short et al., 1976). Further study of the augmented reality chat would be needed to determine if it could be used as a good ice-breaker or to get users comfortable with their tasks before switching to other systems that may be more appropriate for expert users (Kirk, Rodden, & Fraser, 2007). These previously mentioned limitations also did not allow for analysis of conversation that may have indicated if the conversations generated during use of the augmented reality system would be useful inside an educational context.

The surveys could be improved in future studies. It appeared as if the participants became less truthful when they answered the presence survey, potentially because of the unusual semantic differential technique used. Measuring a system on a scale between "warm" and "cold" did not appear to be intuitive, and measuring two systems based on this odd scale may have caused the participants to mentally resign when coupled with the numerous questions to be answered. In addition, both surveys were measured on a seven point Likert scale that may have encouraged the students to choose the middle value frequently, instead of choosing one particular side of the scale. Future studies may wish to choose a different approach to the measurement of presence and keep the number of questions as low as possible.

Another problem with the study is the vagueness of the definition of presence and the related concepts of copresence and social presence (Bioncca, Harms, & Burgoon, 2003). The initial definition by Short, Christie, and Williams (1976) certainly made sense, but their tool for measuring the subjective presence of any one system has not been greatly improved, verified, or changed for use on new developing systems. Typically, researchers merely reach back to the original questionnaire to measure presence. Only recently has there been a focus on creating more reliable questionnaires for presence (Lombard & Jones, 2007). Further work on refining the measurement instrument could lead to a better ability to measure differences in presence between different systems.

To adequately recreate presence more technological innovation may be needed which simply may not be very feasible for the general user. The *Office of the Future* (Raskar et al., 1998) was a project designed to create a good sense of coworker presence, through the use of multiple projectors and software that models the room and makes corrections in the display so that graphics may be displayed perfectly on non-level surfaces. The drawbacks to this system are immense, such as the need for ubiquitous projectors, and a darkened area for all collaboration to take place. Even with this, it may be that the sense of presence from visuals relies heavily on spatial aspects such as visual parallax.

LIST OF REFERENCES

LIST OF REFERENCES

Ahern, T., Thomas, J., Tallent-Runnels, M., Lan, W., Cooper, S., Lu, X., & Cyrus, J. (2006). The effect of social grounding in a computer-mediated small group discussion. Internet and Higher Education 9, 37-46.

Allen, I. & Seaman, J. (2007). Online nation: Five years of growth in online learning. Retrieved 3/30/2010 from www.sloan-c.org/publications/survey/pdf/online_nation.pdf

Anderson, T., Rourke, L., Garrison, D. R., & Archer, W. (2001). Assessing teaching presence in a computer conferencing context. Journal of Asynchronous Learning Networks, 5(2), 1- 17.

Barakonyi, I., Fahmy, T., Schmalstieg, D. (2004). Remote Collaboration Using Augmented Reality Videoconferencing. Proceedings of Graphics Interface 2004, May 17-19, London, Ontario.

Bos, N., Olson, J., Gergle, Olson, G., & Wright, Z. (2002). Effects of Four Computer-Mediated Communications Channels on Trust Development. CHI 2002, Minneapolis, Minnesota, USA.

Bradner, E., & Mark, G. (2001). Social presence with video and application sharing (pp. 154-161). Boulder, Colorado, USA: ACM. doi: 10.1145/500286.500310.

Bruner, J. (1990). Acts of Meaning. Cambridge, MA: Harvard University Press.

Chapanis, A., Ochsman, R., Parrish, R., & Gerald, D. (1972). Studies in interactive communication. The effects of four communication modes on the behavior of teams during cooperative problem-solving. Human Factors. 14, 487-509.

Chen, B. (2009). "IF YOU'RE NOT SEEING DATA, YOU'RE NOT SEEING". *Wired Magazine*. Retrieved 2009-08-26. From HTTP://WWW.WIRED.COM/GADGETLAB/TAG/AUGMENTED-REALITY/.

Chen, Y. (2006). A study of comparing the use of augmented reality and physical models in chemistry education. VRCIA 2006.

Cheok, A., Goh, K., Liu, W., Fabiz, F., Fong, S., Teo, S., Li, Y., & Yang, X. (2004). Human Pacman: a mobile, wide-area entertainment system based on physical, social, and ubiquitous computing. Personal and Ubiquitous Computing 8(2), 71-81.

Christophel, D.M. and Gorham, J. (1995). A test-retest analysis of student motivation, teacher immediacy, and perceived sources of motivation and demotivation in college classes. Communication Education, 44, 292-306.

Clark, H & Brennan, S. (1991) Grounding in communication. Perspectives on socially shared cognition, 127 – 149. American Psychological Association, Washington, DC.

Davies, J. & Graff, M. (2005). Performance in e-learning: online participation and student grades. British Journal of Educational Technology. 36(4), 657-663.

Dourish, P. (2001) Where the action is: the foundations of embodied interactions. Cambridge, MA: MIT Press.

Dunser, A., Steinbugel, K., Gluck, J., & Kaufmann, H. Virtual and Augmented Reality as Spatial Ability Training Tools. (2006) Proceedings from CHINZ '06: 7th Annual Conference of the NZ ACM Special Interest Group. Christchurch, New Zealand.

Ertmer, P & Newby, T. (1993). Behaviorism, Cognitivism, Constructivisim: Comparing Critical Features from an Instructional Design Perspective. Performance Improvement Quarterly 6(4), 50-71.

Fjeld, M. (2004). Usability and Collaborative Aspects of Augmented Reality. Interactions, 11(6).

Fjuk, A., & Krange, I. (1999). The situated effects of awareness in distributed collaborative learning: interactive 3D an example (p. 18). Palo Alto, California: International Society of the Learning Sciences.

Fussell, S., Kraut, R., & Siegel, J. (2000).Coordination of communication: effects of shared visual context on collaborative work. Proceedings of the 2000 ACM conference on Computer supported collaborative work. Philadelphia, Pennsylvania.

Gergle, D., Kraut, R., & Fussel, S. (2004). Action as language in a Shared Visual Space. CSCW 2004, Chicago, Illinois, USA.

Gergle, D., Rose, C., Kraut, R. (2007) Modeling the Impact of Shared Visual Space on Collaborative Reference. CHI 2007, San Jose, California, USA.

Gillet, A., Sanner, M., Stoffler, D., Goodsell, D., & Olson, A. (2004). Augmented Reality with Tangible Auto-Fabricated Models for Molecular Biology Applications. VIS 2004.

Hauber, J., Regenbrecht, H., Billinghurst, M., & Cockburn, A. (2006). Spatiality in videoconferencing: trade-offs between efficiency and social presence. Proceedings of the 2006 20th anniversary conference on Computer supported collaborative work. Alberta, Canada.

Haythornthwaite, C., Kazmer, M. M., Robbins, J. & Shoemaker, S. (2000). Community development among distance learners: temporal and technological dimensions. Journal of Computer Mediated Communication, 6, 1, 1–24.

Hollan, J. & Stornetta, S. (1992). Beyond being there. Proceedings of the SIGCHI conference on Human factors in computing systems. Monterey, California.

International Society for Presence Research. (2000). The Concept of Presence:Explication Statement. Retrieved 12/2/2009 from HTTP://ISPR.INFO/

Ishii, H., & Ullmer, B. (1997). Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms. CHI ‘97, Atlanta GA USA

Jennings, P. (2005). Tangible social interfaces: critical theory, boundary objects and interdisciplinary design methods (pp. 176-186). London, United Kingdom: ACM. doi: 10.1145/1056224.1056249.

Jensen, C., Farnham, S. D., Drucker, S. M., & Kollock, P. (2000). The effect of communication modality on cooperation in online environments (pp. 470-477). The Hague, The Netherlands: ACM. doi: 10.1145/332040.332478.

Jonassen, D. (1991). Objectivism vs constructivism: Do we need a new philosophical paradigm? Educational Technology, Research and Development, 39(3), 5-13.

Jung, I., Choi, S., Lim, C., Leem, J. (2002). Innovations in Education and Teaching International. 39(2).

Kauffman, H., Steinbugl, K., Dunser, A., Gluk, J. (2003). Improving Spatial Abilities by Geometry Education in Augmented Reality - Application and Evaluation Design. "VRIC Laval Virtual 2005 Proceedings", IEEE, 2005, 25 - 34.

Kaufmann, H. & Meyer, B. (2008). Simulating educational physical experiments in augmented reality. International Conference on Computer Graphics and Interactive Techniques. Singapore.

King, F. (2002). A virtual student: not an ordinary joe. The Internet and Higher Education. 5, 157-166.

Kirk, D., Rodden, T., & Fraser, D. (2007). Turn it this way: grounding collaborative action with remote gestures. Proceedings of the SIGCHI conference on Human factors in computing systems. San Jose, California.

Kraut, R., Gergle, D., Fussel, S. (2002). The Use of Visual information in Shared Visual Space: Informing the Development of Virtual Co-Presence. CSCW 2002, New Orleans, Louisiana, USA.

Liarokapis, F., & Newman, R. (2007) Design experiences of multimodal mixed reality interfaces. Proceedings of the 15th annual ACM international conference on Design of communication. El Paso, Texas.

Lin, G. (2004). Social Presence Questionnaire of Online Collaborative Learning:Development and Validity. Association for Educational Communications and Technology, 27th, Chicago, IL, October 19-23.

Lipponen, L. (1999). The challenges for computer supported collaborative learning in elementary and secondary level: Finnish perspectives (p. 46). Palo Alto, California: International Society of the Learning Sciences.

Lombard, M. & Ditton, T. (1997). At the Heart of It All: The Concept of Presence. Journal of Computer-Mediated Communication. 3(2).

Milgram, P. & Kishino, F. (1994). A taxonomy of mixed reality Visual Displays. IEICE Transactions on Information and Systems. 77(12), 1321-1329.

Milgram, P., Takemura, H., Utsumi, A., Kishino, F. (1994). Augmented Reality: A class of displays on the reality-virtuality continuum. Telemanipulator and Telepresence Technologies. Boston, MA.

Minsky, M. (1980). Telepresence. Omni, June, 45–51. MIT Press Journals. (n.d.). Presence. Retrieved April 29, 2008, from HTTP://WWW.MITPRESSJOURNALS.ORG/LOI/PRES

Moore, A., Masterson, J.T., Christophel, D.M., and Shea, K.A. (1996). College teacher immediacy and student ratings of instruction. Communication Education, 45, 29-39.

Morgan, G. (2003). Faculty Use of Course Management Systems. 2, Retrieved November 27, 2005 from www.la.edu/include/learning_resources/online_course.../ekf0302.pdf

Nakano, Y. I., Reinstein, G., Stocky, T., & Cassell, J. (2003). Towards a model of face-to-face grounding. In Proceedings of the 41st Annual Meeting on Association for Computational Linguistics - Volume 1 (pp. 553-561). Sapporo, Japan: Association for Computational Linguistics.

Nardi, B., Kuchinsky, A., Whittaker, S., Leichner, R., Schwartz, H. (1995) Video-as-data: technical and social aspects of a collaborative multimedia application. Computer supported collaborative work. 4(1).

Nari, B., Whittaker, S., & Bradner, E. (2000). Interaction and outeraction: Instant messaging in action. Proceedings of CSCW'00 Association of Computer Machinery.

Ngwenyama, O. & Lee, A. (1997). Communication Richness in Electronic Mail: Critical Social Theory and the Contextuality of Meaning. MIS Quarterly, 21(2).

Parsad, B. & Lewis, L. (2008). Distance education at Degree-granting Postsecondary Institutions: 2006-07. Retrieved November 13th, 2008 from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2009044

Pash, A. (2008). Five Best Videochat Applications. Retrieved March 8th, 2010 from http://lifehacker.com/5088083/five-best-video-chat-applications.

Raskar, R., Welch, G., Cutts, M., Lake, A., Stesin, L., & Fuchs, H. (1998) The office of the future: a unified approach to image-based modeling and spatially immersive displays. Proceedings of the 25th annual conference on Computer graphics and interactive techniques.

Regenbrecht, H., Lum, T., Kohler, P., Ott, C., Wagner, M., Wilke, W., & Mueller, E. (2004). Using augmented virtuality for remote collaboration. Presence: Teleoperators and Virtual Environments. 13(3), 338 – 354.

Richardson, J. C. & Swan, K. S. (2003, February). Examining social presence in online courses in relation to students' perceived learning and satisfaction. Journal of Asynchronous Learning Networks. 7(1), 21-40.

Rovai, A. P. (2002). Sense of community, perceived cognitive learning, and persistence in asynchronous learning networks. Internet and Higher Education. 5, 319–332

Shea, P. & Bidjerano, T. (2008). Community of inquiry as a theoretical framework to foster "espistemic engagement" and "cognitive presence" in online education. Computers & Education. 52, 543 – 553.

Short, J., Williams, E., & Christie, B. (1976) The social psychology of telecommunications. Wiley, London.

So, H. & Brush, T. (2007). Student perceptions of collaborative learning, social presence and satisfaction in a blended learning environment: Relationships and critical factors. Computers & Education. 51(1), 318-336.

Stahl, G., Koschmann, T., & Suthers, D. (2006). "Computer-supported collaborative learning: An historical perspective". In R. K. Sawyer (Ed.), Cambridge handbook of the learning sciences (pp. 409–426). Cambridge, UK: Cambridge University Press.

Tscholl, M., McCarthy, J., & Scholl, J. (2005). The effect of video-augmented chat on collaborative learning with cases. Proceedings of the 2005 conference on Computer support for collaborative learning. Taipei, Taiwan.

Vygotsky, L. (1978) Mind in Society: The Development of Higher Psychological Processes. Cambridge: Harvard University Press.

Whittaker, S. (1995). Rethinking video as a technology for interpersonal communications: theory and design implications. International Journal of Human-Computer Studies. 42, 501-529.

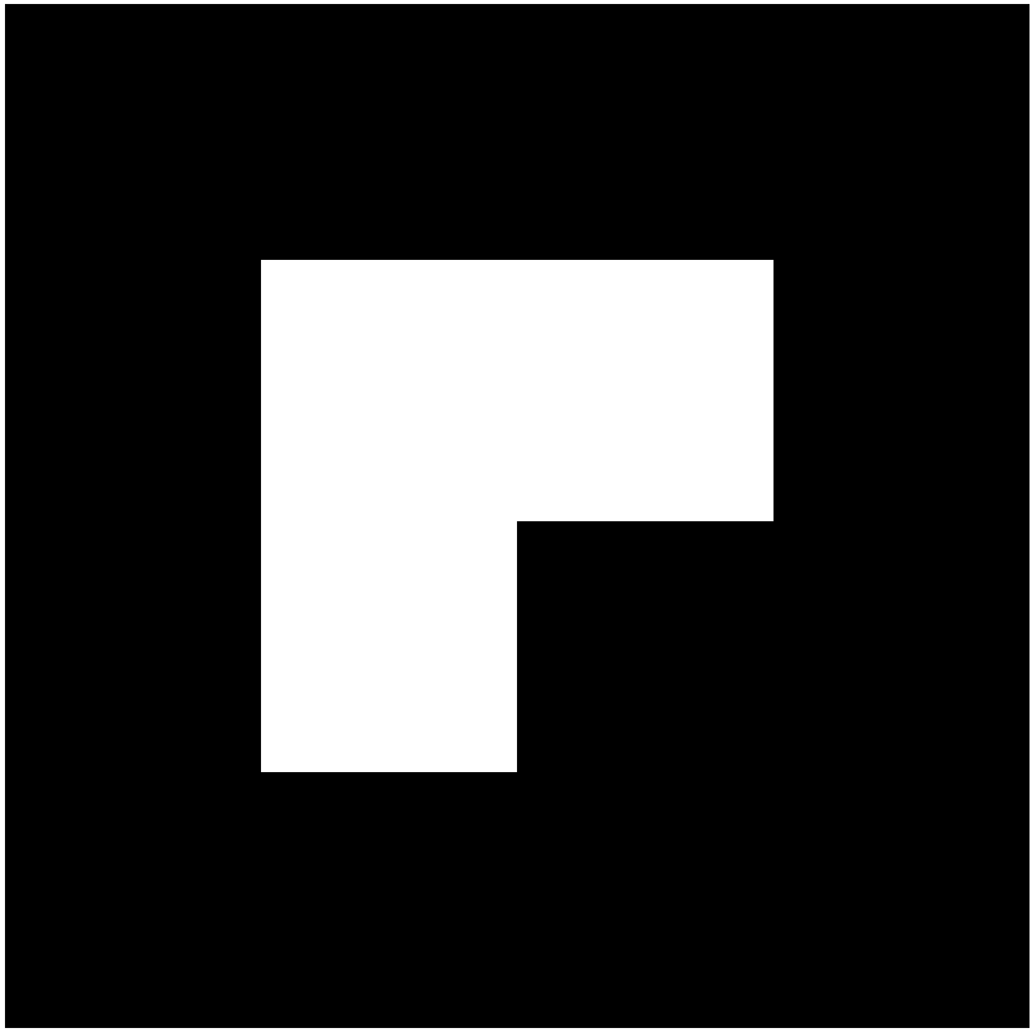
Whittaker, S., Swanson, J., Kucan, J., & Sidner, C. (1997). Telenotes: Managing lightweight interactions in the desktop. ACM Transactions on Computer–Human Interaction, 4(2), 137–168.

Wiener, M. and Mehrabian, A. (1968). Language within Language: Immediacy, a channel in verbal communication. New York: Appleton-Century-Crofts.

Wilson, P. (1991). Computer Supported Cooperative Work: An Introduction. Norwell, MA: Kluwer Academic Pub.

APPENDICES

Appendix A. Fiducial given to the participants



Appendix B. Study Description

Purpose of this study

This study is analyzing the ability of two different systems to create natural interactions between users. The goal is to analyze how each system makes a user feel like they are interacting with a real person, and how much it seems they are not interacting through technology, but in a physically present situation. These types of interactions could lead to better collaboration amongst learning groups.

Introduction

In a moment, the researcher will explain how to use two different sets of software. You will then be given a set of cards with printed icons on them. These are called ‘fiducials’ and will be used for half of the study. After any last questions have been answered, you and your partner will be lead to separate rooms and asked to complete the first task.

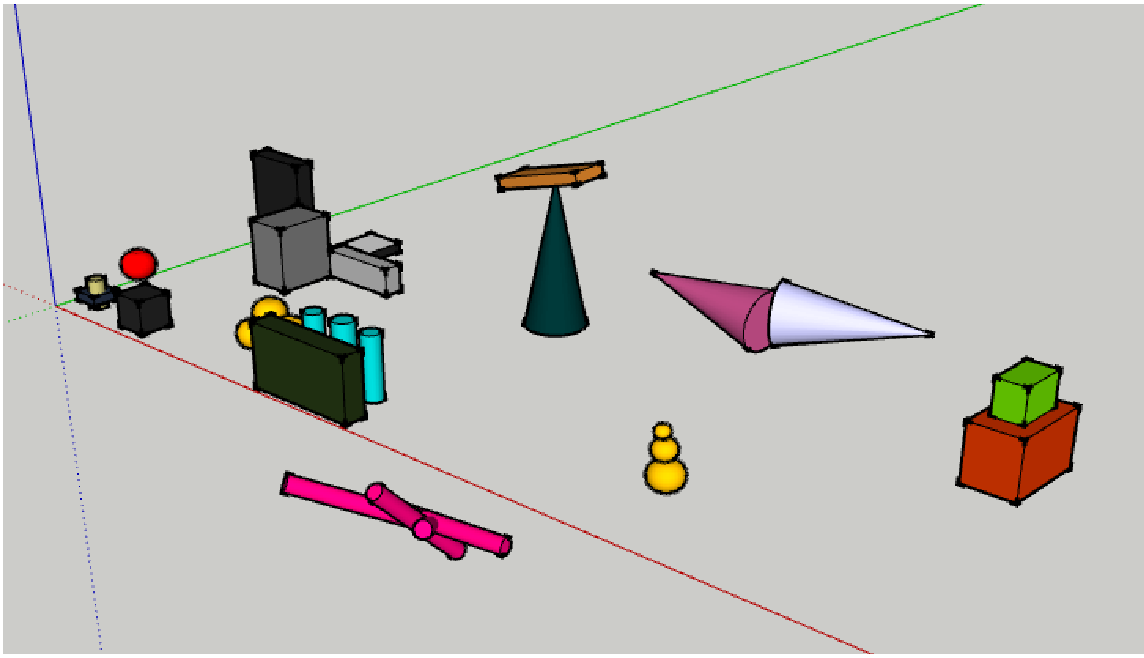
Task 1

With Google Sketchup and GoToMeeting open, sort the blocks present in the sketchup file into groupings that appear appropriate. Take time to discuss your reasoning with your partner. You have up to 15 minutes to complete this task. When agreement has been reached, write down the groupings on the supplied sheet of paper marked “GoToMeeting”. Once finished, close both programs and wait for the researcher to enter and setup the second task.

Task 2

With the augmented reality conference system open, use the fiducials to present different shapes, and again sort them in a logical fashion. Take time to discuss this sorting with your partner. When agreement has been reached, write down the groupings on the supplied paper marked “augmented reality”. When finished, close the program and wait for the researcher to bring you back to the conference room.

Appendix C. Models Used in *Google Sketchup*



Appendix D. Copresence Survey

Copresence survey

Please rate the **GoToMeeting** conference for these questions.

I was always aware that my partner and I were at different locations.	Strongly agree 1 2 3 4 5 6 7 Strongly disagree
I was always aware of my partner's presence	Strongly agree 1 2 3 4 5 6 7 Strongly disagree
It was just like being face to face with my partner	Strongly agree 1 2 3 4 5 6 7 Strongly disagree
It felt as if my partner and I were in the same room.	Strongly agree 1 2 3 4 5 6 7 Strongly disagree

Please rate the **Augmented Reality** conference for these questions.

I was always aware that my partner and I were at different locations.	Strongly agree 1 2 3 4 5 6 7 Strongly disagree
I was always aware of my partner's presence	Strongly agree 1 2 3 4 5 6 7 Strongly disagree
It was just like being face to face with my partner	Strongly agree 1 2 3 4 5 6 7 Strongly disagree
It felt as if my partner and I were in the same room.	Strongly agree 1 2 3 4 5 6 7 Strongly disagree

Appendix E. Social presence survey

Social Presence Survey

Please rate the **GoToMeeting** conference between these sets of words.

Impersonal	1 2 3 4 5 6 7	Personal
Cold	1 2 3 4 5 6 7	Warm
Ugly	1 2 3 4 5 6 7	Beautiful
Small	1 2 3 4 5 6 7	Large
Insensitive	1 2 3 4 5 6 7	Sensitive
Colourless	1 2 3 4 5 6 7	Colourful
Unsociable	1 2 3 4 5 6 7	Sociable
Closed	1 2 3 4 5 6 7	Open
Passive	1 2 3 4 5 6 7	Active

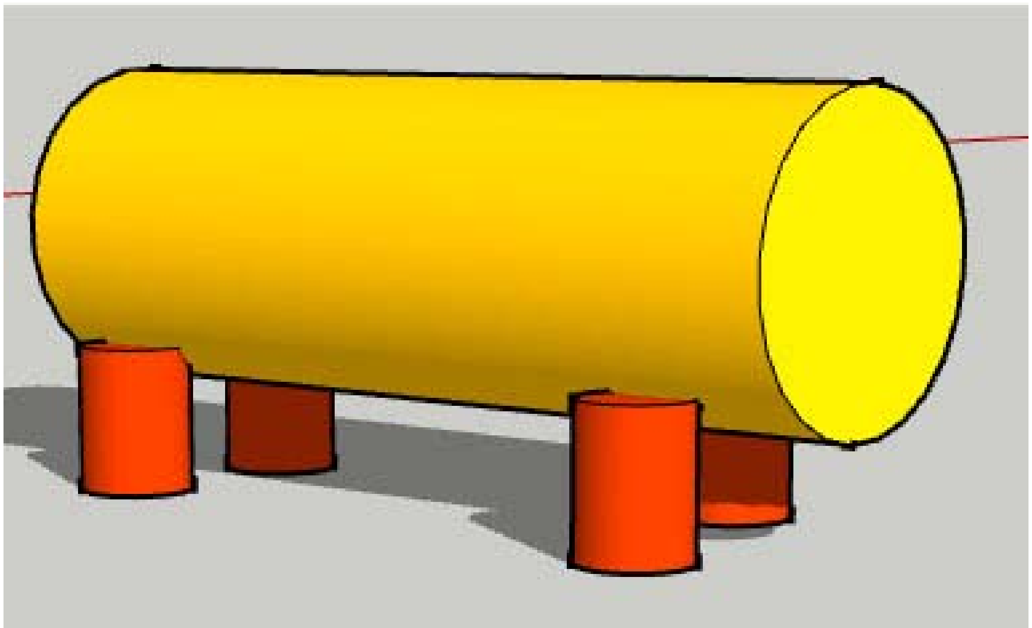
Please rate the **Augmented Reality** conference between these sets of words.

Impersonal	1 2 3 4 5 6 7	Personal
Cold	1 2 3 4 5 6 7	Warm
Ugly	1 2 3 4 5 6 7	Beautiful
Small	1 2 3 4 5 6 7	Large
Insensitive	1 2 3 4 5 6 7	Sensitive
Colourless	1 2 3 4 5 6 7	Colourful
Unsociable	1 2 3 4 5 6 7	Sociable
Closed	1 2 3 4 5 6 7	Open
Passive	1 2 3 4 5 6 7	Active

Appendix F. Demographics survey

Age	
Sex	Male Female
Experience with web conferencing systems	None Some Intermediate Expert
Have you used augmented reality software before	Yes No
Have you seen augmented reality before	Yes No
Major	
Computer experience	None Some Intermediate Expert

Appendix G. Model viewed in ARchat



Appendix H. Post task interview questions

Social presence interview questions

What was annoying with each system?

What was good about each system?

If you could change one thing in each, what would it be?

Did using the augmented system feel more natural?

If you had to do a similar task again, which system would you prefer?