Interactions within a Shared Graphic Space

Carmel John Vaccare

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Glen A. Holmes, Co-chair
Susan G. Magliaro, Co-chair
John K. Burton
J. Thomas Head
Ned K. Swartz

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(ABSTRACT)

This study is an examination of issues affecting the use of a shared graphic space (SGS). A working definition for an SGS is a virtual, computer-mediated blackboard that allows the simultaneous presentation and editing of visual information by two or more participants. The issues affecting the use of an SGS involve how people communicate with it. The addition of any technology into an already complicated situation like distance learning should be examined from multiple angles. In order to examine an SGS as a channel for communications, this study framed the SGS in terms of the nature of the feedback and noise that are present when we examine interactions in this space.

This study examined 16 dyads interacting with whiteboard software to communicate solutions to 6 tangram puzzles. In all problem sets, participants used the text inherent in the whiteboard software as well as graphics to communicate potential solutions with each other in dyads. The participants also had access to audio for communications during either the first 4 or final 2 problem sets.

Analysis of the results of this study show that the use of graphics for communication is dependent on accompanying communication channels. The addition of an audio channel for communications inhibited the use of text for communications. Graphics were used concurrently with audio as a dynamic enhancement to verbal communications. Graphics were not used concurrently with text. Graphics either occurred before or after text and were used as static illustrations or were used independent of text. The feedback mechanisms for the SGS were largely through the text or audio modes of communication.

The graphic capabilities inherent to the SGS were an affordance to present and manipulate visual information. The SGS encourages new ways to interact and unique patterns of interactions between users. The manner in which graphics were used by each dyad was determined by the dyad and did not conform across the dyads. The unstructured nature of the SGS was a contributing factor in causing differentiation of the inter-dyad communication from intra-dyad communication. This lack of structure in the SGS was a source of noise in, as well as a source of freedom for, interactions in the SGS. The development of an etiquette for interacting in this unstructured space was developed dynamically and pragmatically and should be a source of future study. Shared space, that can be used for simultaneous, real time communications with graphics, changes the manner in which teachers and students can collaborate and construct new learning environments.

Dedication

To my father and grandfather.

Acknowledgements

This document is due in no small part to the people who have passed through my life.

… to the members of my committee: co-chairs Drs. Glen Holmes and Susan Magliaro, and Drs. John Burton, Tom Head, and Ned Swartz whose encouragement and faith in my abilities got me through.

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But most of all, this may not be a result of the women who have passed through my life, but it is due in no small part to them.

… the one who gave me life and the one I shared half my life with.

… the ones who got me through this and the ones who gave support. Sisters and secretaries who kept me on track .

… the ones I lost and the ones I found in unexpected places.

… the ones who made me smile in spite of myself.

Thank you one and all.

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Introduction

Text has been the predominant mode in Computer Mediated Communications (CMC). The capability for communicating with graphics for mathematics, the sciences, engineering, etc. has been lacking. Non-text information has either been available through hard copy (books, faxes, etc.) or through graphic images viewed through separate software packages or the World Wide Web. Up until now, the ability to interact for editing and highlighting existing graphics, as well as create and share new images, has been available only through expensive proprietary hardware and software. Although computer delivered video for conferencing is increasing, graphics are only available for presentation *to* people, not interaction *between* people. This is a study on the use of graphics for communication through a computer mediated whiteboard. This document introduces the concept of a shared graphic space (SGS), provides a rationale for its use, and presents a study designed to describe the nature of the graphical interactions in this space.

The first chapter defines and illustrates a computer mediated SGS where people can communicate through a virtual electronic whiteboard. Other existing forms of computer mediated communications (text, audiographics, video) are then introduced for comparison purposes. Since there does not exist a direct theoretical base for an SGS, this chapter proceeds to support the use of an SGS through current literature on CMC. Models are then presented from communications literature to illustrate the contributions of feedback and noise inherent in all communications channels. Assuming communication results in the creation of meaning, Vygotsky's Zone of Proximal Development (ZPD), and the concept of scaffolding warrant investigating the use of an SGS for a learning environment.

The methodology in the second chapter is based on a quantitative/qualitative post-positivist paradigm (Guba & Lincoln, 1994). The identification and classification of interactions according to sequence and time lend themselves to a quantitative approach. The nature and use of the graphic interactions lend themselves more to a qualitative approach. This dual perspective is addressed through the design of an experiment to isolate the nature of the interactions in the SGS. The chapter lays out the setting, hardware, participants, and data acquisition process for the study of the graphic interactions in an SGS.

Chapter 3 presents the results of the investigation separated into quantified and descriptive sections. The quantified section breaks the results into time and occurrence of events in order to derive what is common to all participants and unique to some participants. The descriptive section presents observations on the actual use of the space in order to create a better understanding of how an SGS was used. The results are supported throughout by computer screenshots of the whiteboard, tables of quantified data, and the responses to a post-session questionnaire.

The final chapter unifies the previous chapters and presents possible avenues for further inquiry. The sample size was small, initially 38 participants, and the study preliminary, so generalizations and conclusions are not warranted.

Chapter 1
Literature Review

This chapter reviews the research and general education literature related to CMC and the potential for creating a different space for learning to occur. The first section introduces the definitions, examples, and ideas surrounding the concept of a shared graphic space (SGS). Support for using an SGS is presented from existing CMC literature. In order to identify important attributes of the graphics in an SGS, models from communications literature are introduced. The final section of this chapter ties the use of an SGS to Vygotsky's Zone of Proximal Development (ZPD) (1978) and the concept of scaffolding (Brown & Palincsar, 1989; Rogoff & Gardner, 1984).

Definitions and Examples

A working definition for an SGS is a virtual blackboard that allows presentation and editing of visual information by two or more participants. Presently, the most common embodiment of an SGS is the whiteboarding software included in most computer conferencing software.

Whiteboarding software for electronic conferencing is used in conjunction with text-based "chat " and/or audio functions. In simple terms, "chat" can be thought of as a text-based phone conversation, where the audio function is similar to a normal phone conversation. Some conferencing packages even allow application sharing, which occurs when a person on one computer can run a software application on a remote computer. A definition of whiteboard from the Electronic Computer Glossary (1994) is "[T]he electronic equivalent of chalk and blackboard. Whiteboards allow participants across a network to simultaneously view one or more users drawing on the computer." The network used can be Internet, local area network (LAN), wide area network (WAN), or a direct modem to modem connection.

Whiteboarding is also found in videoconferencing systems that use dedicated connections. Some packages incorporate the ability to edit documents while others only permit overlaying comments and graphics. All of them allow capturing and saving the editing space as a graphic snapshot. Some will also allow direct loading of documents created by other applications. For example, a report can be loaded into a software "slide tray" for presentation and editing. Pre-existing information can then be used for a conference. The trend by Microsoft and Netscape is to incorporate conferencing technology into their Internet browsers and/or the operating system.

Competition exists among software and hardware companies to increase their conferencing and groupware market share in the business. Conferencing software can permit real-time construction, editing and sharing of documents by two or more people, where groupware can permit several people to construct, edit and revise a document at different times. This competition is changing conferencing software from proprietary, business-oriented, and expensive to readily available, ubiquitous, and inexpensive. This transition is likely to increase the use of conferencing software, and, therefore, whiteboarding.

Determining whether there are appropriate educational uses for whiteboarding will require research, reflection, and evaluation.

Conferencing software is available for a variety of operating systems. Some versions are cross-platform and some can be run in low bandwidth situations, including ordinary telephone service. Although the software can be awkward to use and requires training, it is becoming more user friendly with time. A screen shot of Microsoft Netmeeting's™ (1997) whiteboard (see Figure 1), is representative of the interface found in most packages.

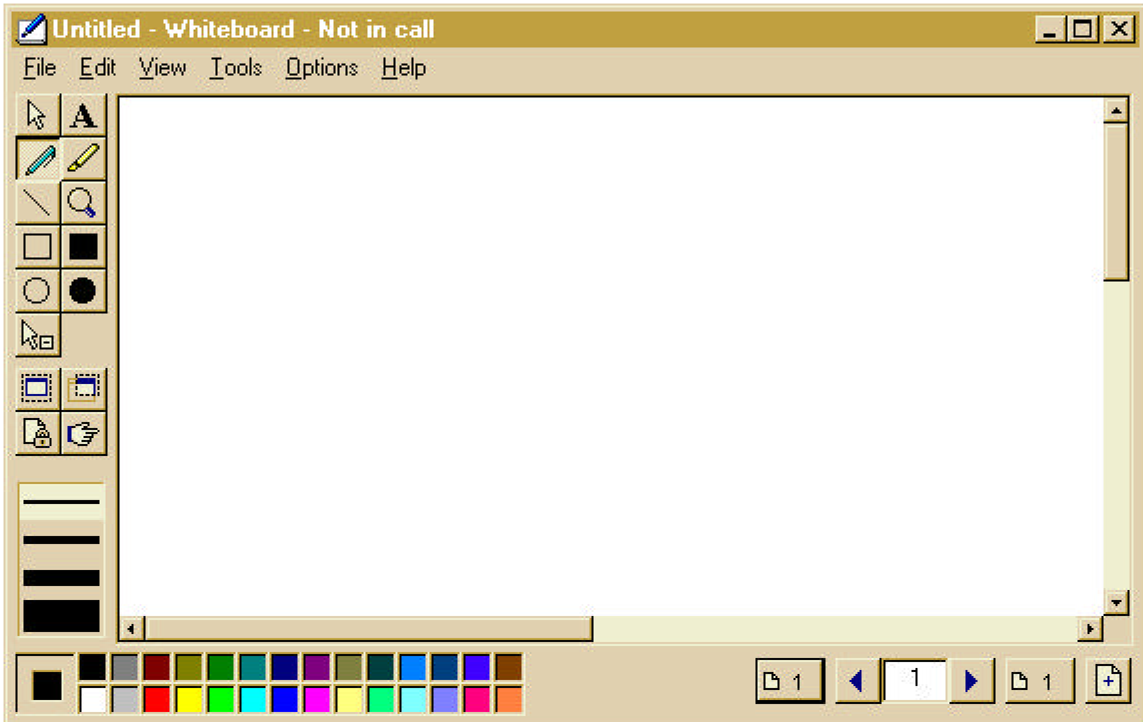


Figure 1. Screenshot of Netmeeting's™ whiteboard.

Note the similarities with basic paint programs such as Quickdraw for the Macintosh and Paint for Windows. The toolbar on the left of the drawing area (whiteboard) contains simple drawing tools and a standard menu is along the top. The whiteboard editing space can have pictures, text, or regions of the computer desktop pasted or entered into it. Pictures from a digital camera or scenes from video playing in a background application can also be easily captured and pasted into the whiteboard. If it can be displayed on a computer screen, it can be placed in an SGS.

The data can then be drawn on, edited, or commented on using text entered directly into the space by multiple participants. Netscape's CoolTalk™ conferencing software permits only two conferees at a time. Other packages, like Microsoft's Netmeeting™, can support more participants, and some incorporate a system of controlling who has the editing capability at any given moment. Communication standards such as International Telecommunications Union's (ITU) T.120 open standard, permit low bandwidth, cross platform data sharing conferences that are independent of a particular software package. Anyone using

Netmeeting™ should then be able to communicate with someone using Cooltalk™, or other ITU T.120 compliant packages, with whiteboarding, application sharing, and data exchange. The latest versions of conferencing packages usually support the Consultative Committee for International Telegraphy and Telephony's (CClTT) H.320 standards for platform independent, higher bandwidth network use. H.320 is a compilation of standards for desktop videoconferencing. These standards define three levels of compliance (minimum, optional, and maximum) of support for sharing audio and video among computers. However, these standards do not specify the quality of that support, just as two TV sets can receive the same channels with a marked difference in picture and sound quality. The latest H.323 standard supports videoconferencing down to 28.8 Kbps.

A Possible Scenario for Using a Shared Graphical Space

A computer lab at a public school is used in conjunction with on-line classes offered through a local college. The facilitator in the lab is not an expert in any of the courses available on-line, but is trained to proctor activities and tests as well as assist with common hardware and software problems. Students can log on to a variety of asynchronous courses in which they are enrolled. No single course is offered in the lab. Rather, the students can enroll and take courses according to their personal schedules. Faculty and assistants at the college are on-line to answer questions from the multiple sites. Because of financial constraints, the instructors for a given discipline are available on a rotating basis and only for courses currently offered. When a student working on an assignment has a question and logs a conference with an instructor or facilitator, the screen can look like Figure 2.

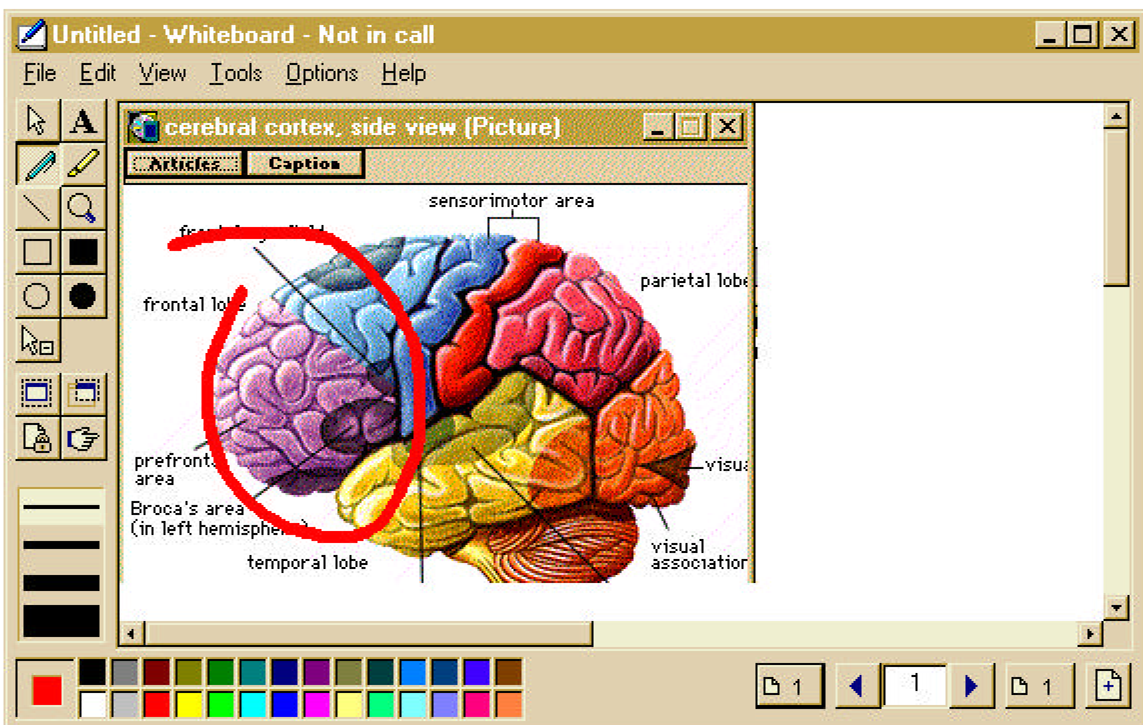


Figure 2. Screenshot of Netmeeting's™ whiteboard with a pasted image.

A student in an anatomy class has pasted a screen shot from a dictionary (Grolier Multimedia Encyclopedia, 1995), and circled a section of interest. While the student discusses her problem through the audio capabilities of the software, she can point to, highlight, cut and paste on the graphic to illustrate her point as the instructor loads new images or further edits the student's commentary. At any given moment in the conference either the student or a facilitator can capture and save the information on the whiteboard for future reference. Depending on the available bandwidth, the instructor and student can use simultaneous audio and an additional "chat" window (see Figure 3), where a running text commentary can occur.

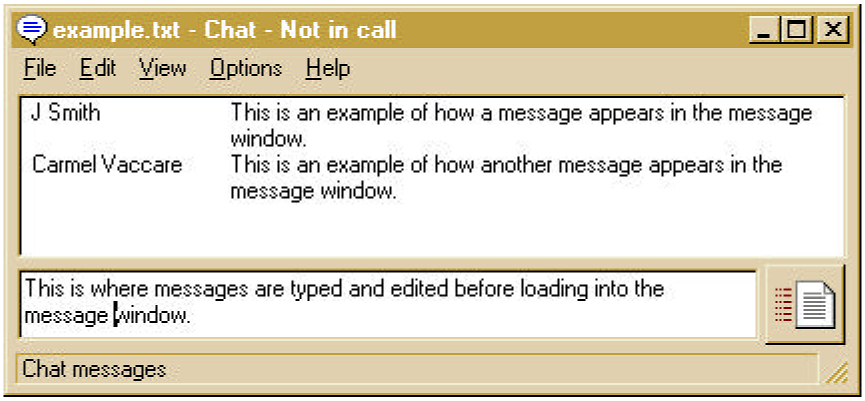


Figure 3. Screenshot of Netmeeting's™ chat window.

At a lower bandwidth, just the chat feature can be used with the whiteboard or an additional phone line can be used for audio. Note that there could be a session with multiple students attending a virtual lecture. A student can be at home with a personal computer logging in at appropriate times, or students can collaborate on assignments with each other.

Hardware Trends

Four pieces of technology are in place to make the above scenario work:

1) New modems with simultaneous voice and data capabilities are now in the marketplace so that a single phone line may be used for voice and data.
2) The base computer for sale at the local discount store is likely to have sound capabilities.
3) Current Internet access to the home is available at 14.4 K speeds in most areas of the country and is likely to increase in availability and bandwidth in the near term.
4) Internet capable TV interfaces incorporating high speed modems cost less than $400 with a $15 per month access charge.

This is not to suggest that all schools are so equipped, but studies and planning documents for the State of Virginia suggest that high bandwidth (T1,1.5 Mbps, or greater) access to the Internet will occur in the immediate future for all schools (Virginia Information Technology Infrastructure Task Force, 1995; VCCS Information Infrastructure Task Force, 1994). Network Virginia (http://www.networkvirginia.net/) is another initiative to link educational institutions across the state of Virginia to a high speed Asynchronous Transfer Mode (ATM) network. Additionally, revisions of the FCC Telecommunications law encourage K-12 Internet access through a system of discounts based on need and location. The Internet then becomes a non-proprietary WAN (wide area network) supporting data communication between schools, businesses, and homes.

Different Methods of Computer Supported Communication

Advantages and disadvantages of text, audio, graphics, and video for computer supported communications are presented below. This review of the different forms of CMC, will attempt to show how these forms compliment one another, resulting in improved communications.

The most common tools used for CMC are text-based such as a bulletinboard, listserv, chat session, and email. Bulletinboards and listservs are asynchronous communication systems that place text responses (postings) in a common directory. For instance, a bulletinboard or listserv on biology would provide only information directly related to biology concerns or perhaps related to a particular audience or course of study. Bulletinboards and listservs can be more focused on a topic and can even be threaded. Threading a series of messages results in responses to a particular message being grouped with that message. Instead of searching through all of the postings, those of interest can be easily accessed. Email can be used to post to bulletinboards and listservs or it can be a more personal/direct form of electronic letter writing. Chat was described earlier and is normally considered a synchronous form of communication as opposed to email which is asynchronous. Synchronous and asynchronous are defined and described in a later section.

Text-based forms of communications place the student with weak reading and/or writing skills and/or poor typing ability at a disadvantage. In a chat session, the text appears as a block of text when entered. A worst case scenario could be that a slow reader will take a longer amount of time to read. Moreover, if that student is a slow typist, s/he will take a longer amount of time to respond. Since chat sessions are not threaded, the responses are not grouped. A slower student's responses require going back in the session to reference the original statement that prompted the response. Also nonverbal cues are at best handled with emoticons (which resemble sideways faces, for example :-) :-(;-) :-o, etc.), or at worst are nonexistent (Holden & Wedman, 1993). Holden and Wedman's 1993 Delphi study of higher education faculty who use CMC presented a consensus that the lack of nonverbal cues is not a barrier in using CMC. This would seem to point to a possible lack of appreciation for the technology's <u>overall</u> effect on students. Kiesler, Siegler, and McGuire (1984), in discussing their research on social aspects of CMC, report that the "... lack of nonverbal involvement is a critical dimension of electronic communication" (p.1131). Present research has not altered this assessment. Nonverbal cues may not be necessary to use CMC, but they can support effective communications.

Another deficit of text-based communication is the difficulty in describing tangible items. A picture can truly be worth a thousand words when mental images (concepts, visualizations, interpretations) derived from text can differ greatly among readers. The use of graphics can reduce ambiguity in presenting and communicating concepts to and among students. Returning to Figure 2 and describing an area of the brain without graphics could be tedious and difficult. The inability of text-based systems to present symbols for math and the sciences presents another problem that can be solved in a graphical environment with an SGS.

Text-based communication has an advantage in that it supports empowerment. Davie and Wells (1991) consider "... the implications of a text-based dialogue..." (p. 16) and the "... democratic openness ..." of CMC (p. 18) to the less assertive, disabled, stereotyped, etc. The elimination of visual and aural forms of communication may be important for this form of empowerment by increasing anonymity and, therefore, eliminating information that can be used to support biases. However, the lack of visual and aural communication then places an additional burden on the communicant's verbal prowess because other important cues might also be omitted (Ishii, Kobayashi & Grudin, 1993; Kiesler et al., 1984). This sense of something missing in the communication leads to compensation or the use of additional modes of communication. For example, adaptations of the system in the form of symbols like emoticons use what is available to create compensatory subsystems to communicate what is missing, in this case, affect. When available, graphics, animations, or video may be used to communicate that which is difficult to describe with words.

Audioconferencing possesses similar weaknesses. Audiocoferencing uses an audio channel or phone bridge as the primary means to communicate and refers to either fax or predelivered hard copies of graphics. The visual information is reduced to static images. Verbal self-expression (especially with no active visual cues) can be awkward at best and gives advantage to the loquacious at the expense of the reticent. Difficulties in expressing formulas and logical constructs are again a problem. Imagine sitting through a lecture on something as mundane as fractions without visual cues. Audiographics which consists of an audio channel (one way or bi-directional) with graphics that are either faxed, predelivered, or otherwise presented, can be used for delivery in such situations. However, the graphic material is static and does not lend itself to manipulation for collaborative approaches. The student(s) and instructor can refer to common documents, but they cannot directly show points of contention or confusion, let alone jointly edit them. They must describe and refer to landmarks on the page and trust they are looking at the same spot. This takes time and can cause a loss of momentum in the conversational moment. Ishii, Kobayashi, and Grudin (1993) address this problem through the use of "gaze awareness" (p. 365) where translucent images of an SGS and the communicants are merged into a single visual field called a ClearBoard. Their system of combining direct visual contact and an SGS replaces the asymmetry of spaces that do not supply strong cues (Gaver, 1992). Gaver identifies those "media spaces" as affording symmetric access which allow people to both see and hear each other without restriction. The shifting of attention is the main problem they seek to address. The technology for that type of interaction is specialized, expensive, and not readily available. But it does highlight the importance of interaction through, not with, computers (p. 373).

Text and audio are streams of information that require serial processing before comprehension. Seeles (1994) cites that verbal language is sequential, discursive, and denotative; where visual language is simultaneous, presentational, and connotative (Langer, 1951; Seeles, 1994). Discourse in conferencing is more about knowledge acquisition and concept attainment than skill development (leaving aside communication and social skills, of course). In studies on both group decision making (Kiesler et al., 1984) and the virtual classroom (Hiltz, 1993), differences in the processes and outcomes are asserted while no difference in overall learning is supported.

If video is seen as similar to educational videotapes with minimal interaction then it is no different than lectures. Educational videotapes reinforce a "transmission view of instruction" (Cognition and Technology Group at Vanderbilt (CTGV), 1993). Visual cues exist but the space is presentational, constrained, and unidirectional. Although referred to as interactive video, the display on a monitor is not shared space and the same dynamics found in most classrooms remain. Students are not free to interact with the material being presented and the instructor remains the gate keeper for student interaction. The student must guide attention to landmarks on any displayed image, but cannot edit or highlight them directly. Though they may enhance personal communication, video systems must be coupled with additional technology to allow document sharing or joint editing visible to all participants. In considering that face-to-face meetings can foster bonding at the expense of "social equality" (Davie & Wells, 1991), one should ask if CMC promotes a more open discourse when video is not present.

Support for Using an SGS

The use of a shared graphic space has received little attention in the educational literature. In a report on designing a whiteboard interface and testing its usability among high school students, Sugar and Boling (1995) state that "... we have found no published studies on incorporating an interactive whiteboard in educational settings ..." (p. 564). Yet some relevant information exists. In a video on distance learning, a representative of Sun Microsystems asserts that the ideal numbers are 6-9 whiteboard participants and that 12 is a maximum (Marcucci & Hacking, 1996). It would appear heuristics exist but documented research is scant. By identifying and referencing a sample of related media literature, inferences may be drawn as to the possible outcomes of using a shared graphic space.

Vossen and Hoffman (1995) conducted a recent study of a software package for remote access of a computer. Timbuktu™ software allows a computer (host) to be controlled or viewed by another (guest). This ability to take over another's computer shares some relevant features with an SGS, but it also lacks some important features. Controlling a computer is not the same as freely interacting in a computer mediated environment. The ability to run an application remotely and allow a student or instructor to monitor the "action" or inject editorial comments is similar to a whiteboard. However, if a paint program were being run remotely, it could be used as a shared graphic space <u>without</u> the ability to take documents or applications on the observer/controller machines and interject them into the space. The results of the study using Timbuktu™ found that "[P]arallel working on the screen is unstructured and requires the discipline of the users and adequate agreements in advance. Two people working on the same screen can disturb each other..." (p. 191). This issue of etiquette is long standing (Kiesler et al., 1982). Vossen and Hoffman also concluded that " a speaking mode could provide important improvements" (p. 192). Missing in programs like Timbuktu™ are integrated control and interaction features as well as the capability to load information from a local machine to the host computer, although sending files can be supported.

In a review of studies on dynamic visual displays (defined as any graphical or pictorial movement) in instruction, Park and Hopkins (1993) found that, in addition to the theoretical justifications for various presentation and simulation uses, dynamic visual displays are effective in providing guidance and analogy. Because of the graphic interaction, the SGS is more than a static display and may therefore be supported by that research.

Clark and Salomon (Clark, 1991; Clark & Salomon, 1986) assert that media in and of itself may not influence or motivate learning. But Clark (1991) does endorse methods for psychological support. Clark defines method as ".. any way to shape information that compensates for or supplants the cognitive processes necessary for achievement or motivation" (p. 35). The use of any media that enhances communication and/or eliminates barriers to understanding can then fall under this definition.

The pictorial superiority effect (Levie, 1987) refers to the ability to recall pictures better than words (Shepard, 1967). More realistic images can facilitate a learner in generalizing to reality (Dwyer, 1978). A caveat is that the greater the visual realism the greater the difficulty in extracting essential information (Dwyer, 1978). The pictorial superiority effect can therefore be used to justify an instructor sharing graphics with students to isolate essentials and direct attention. This facilitates learning when the student is most open to information in a manner that can be superior to words for retention.

Visual information is encoded in different ways than verbal information and in different sensory and language subsystems (Paivio, 1979). The use of an SGS for communication becomes more than a convenience with support from the Dual Coding Theorem (DCT). The DCT gives credence to supporting images with audio (Paivio, 1979). The DCT states that visual and verbal information are processed differently in that verbal information is "organized in terms of associations and hierarchies" while visual information is "organized in terms of part-whole relationships" (Kearsley, 1996). The theorem then asserts that by using verbal and visual information together, learning is improved through redundancy as well as by encoding information in more appropriate manners.

Hsia (1968) recommends keeping cross-channel redundancy high in audiovisual (multiple-channel) presentations. Hearing/seeing the similar content reinforces retention to a point. There is no increase in learning if multiple channels do not have one channel supported by cues in another channel or if a channel is otherwise disturbed or interfered with by stimuli in other channels (Hartman, 1961a). Hsia (1968) states that one channel provides cues or clues for another, provided channel capacity is not reached. This supports the idea of using audio for providing cues to the SGS. Hartman (1961a) concludes that "[U]nder conditions of interference between pictorial and verbal information, the most difficult information (pictorial) is the least affected by the competition" (p. 42). Dwyer's (1978) interpretation of research in this area also supports the contention that audio suffers more than visuals from simultaneous delivery. This would give credence to using audio for support of graphics and not the other way around.

As the number of channels of information increases, the “competition” for short term memory space increases. Miller’s 7±2 chunks (Miller, 1956) and Simon’s (1974) time limits for transferring chunks to long term memory (5-10 seconds per chunk) illustrate the problem. If short term memory is limited in what it can hold and how long it can hold it, then that becomes a bottleneck for long term storage. Multiple channels can then have negative effects through overloading (Hartman 1961b; Hsia, 1968).

According to Salomon (1981, 1983), the reduction of the amount of invested mental effort decreases the cognitive overhead in learning. Mental effort is reduced through the use of graphics because it eliminates the process of translating verbal descriptions to mental images. The effort and energy saved can then be applied elsewhere. However, research from Salomon (1983, 1994) and from Britton, Westbrook, and Holderidge (1978) indicates a positive correlation and causation between applied mental effort and learning. Students invest more effort in difficult media and consequently learn more. The conflict in the above information is that easier is not always better, but easier to <u>use</u> should not be confused with media delivery and content. A problem with students believing that one media is “easier” than another is that attention suffers with a concomitant decrease in retention (Salomon, 1983, 1994). Keeping an active engagement through an SGS can offset attention drift by forcing interaction.

Clark and Salomon (1986) concluded that research on media has shown that “...no medium enhances learning more than any other medium regardless of learning task, learner traits, symbolic elements, curriculum content or setting” (p. 474). But Clark and Salomon also admit that some media can provide more efficient or effective means of delivery and further suggest that some media attributes can affect learning. None of these studies are concerned with communication. They focus on presentation of material, and their conclusions support instructional design as the “critical element in student achievement” (Johnstone, 1991, p. 55). Studies of interactive technologies usually concern applications of text, audio, video, or interface design.

Moore discusses three types of interaction; learner-content, learner-learner, and learner-instructor (Moore, 1989; Wagner, 1994), all of which are supported in CMC. A follow-up article by Hillman, Willis, and Gunawardena (1994) support Moore and then discuss the addition of a fourth interaction (learner-interface). Norman (1990) wrote that the interface should “..be something that aids ... does not get in the way … does not attract attention and energy to itself” (p. 210). If “... interactivity is active learner participation in the instructional process ... ” (Livengood, 1987, p. 29), a problem occurs when the skill required to participate is over and above the subject matter nominally being taught (Wagner, 1994). As stated previously, it would appear that anything that decreases the cognitive overhead for the instructional process and/or is not related to the instructional content increases the energy that can be supplied to learning. An interface that does not take into account some individuals’ difficulties in text-based communication is inherently flawed in this regard.

Communication within an SGS

An SGS can be viewed as a communication channel. The way to understand the capabilities of the channel for educational use requires framing an SGS in the terms normally associated with communications. Time and place relationships combine with models of communication systems to frame the SGS as a communications medium in the following sections. The SGS is then examined in the next section for its role and impact within a learning context.

Synchronous/Asynchronous

The American Heritage Dictionary defines synchronous as “**1.** Occurring or existing at the same time. **2.** Moving or operating at the same rate.”

Traditional lecture courses are synchronous, the students hear lectures as they are presented. A satellite delivered course is synchronous with the variation that the students are in different locations. An SGS is a predominantly synchronous space for the exchange of data. Interaction occurs “real time,” which is to say that there is minimal delay between the time something is entered into the space and the time it is available to all participants working within the space.

Asynchronous instruction takes place independent of time and is increasingly identified with independence of place. Asynchronous CMC occurs through email, listservs, or bulletinboards where participants read and respond to topics at their convenience. Prime examples of asynchronous instruction are correspondence courses with or without media supplements (audio/video tapes, computer programs for tutorial or drill). A way to exploit technology to increase learning is to move away from synchronous instruction, the traditional lecture class and satellite delivered instruction mentioned earlier, to an open learning environment that encourages self-directed and personally meaningful experiences.

When comparing synchronous versus asynchronous communication, other advantages for a shared space become evident. Just as a frame of motion picture film is an asynchronous snapshot of synchronous events, the dynamic graphic space can also be frozen in time as an asynchronous snapshot of a conversational moment. But there is a definite advantage in advocating the use of a primarily synchronous technology like an SGS. The advantage lies in creating a media rich conversational space where immediate, meaningful feedback is present and teachable moments can occur.

Communication Models and Noise

It is possible to place an SGS into various communications models. For instance, in Shannon and Weaver’s model (Heinich, Molenda, & Russell, 1993; Littlejohn, 1978; Neulip, 1996; Shannon, & Weaver, 1971; Wagner, 1994), the student and teacher exchange roles of source and destination depending on the conversational moment (see Figure 4). The important aspect of this model is the noise which is associated with the channel. Note the absence of any feedback.

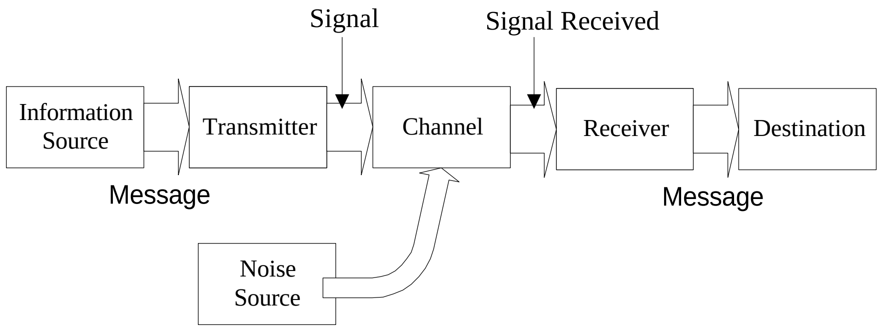


Figure 4. Shannon and Weaver's communication model.

Viewing an SGS as the channel, the noise could be anything that affects the physical representation of the information. Noise inherent to electronic communication results in a grainy TV signal, static, dropped bits, etc. Other ways of looking at noise are that it can be any distraction that "... interferes with the ability of a message to be transmitted or received..." (Wagner, 1994, p. 23) or that " ... competes with a message" (Neulip, 1996, p. 169). Under these definitions, slow typing in a text driven, synchronous dialogue could be interpreted as noise.

At this point, the question of what constitutes a channel becomes important. By viewing the transmitter, receiver, source, and destination as individual information channels in their own right, this model can be scaled and adapted to different micro and macro representations. Noise can originate within a participant as misconceptions, improper use of terminology, and physical difficulties. In some cases, " ... apparently peripheral tasks -like the extralinguistic supports involved in the interpretation of communication - are often dismissed as 'noise' from which salient features can be abstracted for the purposes of teaching" (Brown, Collins, & Duguid, 1989, p. 34). This perception of noise as an important aspect that is sacrificed to get at the core knowledge base, independent of situation, is a prime difference between the exposition of facts versus the communication of concept. Noise can decrease comprehension while increasing attention and immediate acceptance of persuasive messages by inhibiting counter, as well as supportive, arguments (Neulip, 1996). On the other hand, any difficulty in communicating a concept between people is destructive noise in the channel.

A problem that exists in an SGS is that as soon as a picture is presented, any connotations to the image become a slave to the denotation (Langer, 1951; Seeles, 1994). For example, the word tree has rich connotations, but as soon as you encounter a picture of one as an illustration, the illustration becomes the definition for future discourse in that situation. In this case the more concrete image can interfere with communication and be interpreted as noise.

If a student has difficulty in transcribing his thoughts, it is not the accuracy of the thoughts that are evaluated but rather what is communicated. “Partial miscommunication or divergence of readings from a single text, are not aberrations. They are tendencies inherent in the system, which can only be counteracted by continuous effort and by large amounts of verbal interaction” (Reddy, 1982, p. 295). Thus, verbal difficulties become transmission problems, noise. The communication channel becomes a limiting factor in what can be communicated. The ability to ensure that what is transmitted is received becomes dependent on expertise in controlling the system.

A more insidious noise would be confusing the representation for the reality. An excellent example from a group of studies is a video course where the interpretation of a triangle’s attributes were affected by the medium. (The reference for this example has unfortunately been lost.) School children learning about a triangle (and their poorly prepared facilitator) accepted as “fact” that a triangle has curved sides. This was due to the curvature of the monitor’s viewing surface. A lone student who disagreed was pressured to the point of tears to recant her heresy of believing that the sides were straight. Seeing is not always believing.

The SGS increases the opportunities for successful communication by increasing the capabilities of the channel. With increased capabilities comes a concomitant increase in the potential for misinterpretation, noise. This brings up the importance of feedback in a system.

Feedback

Cybernetics views processes in general as containing feedback for regulation and control (Littlejohn, 1978). A simple system is nothing more than an input, an output, and a feedback path for regulation. The box in Figure 5 can represent the student or teacher who in some manner modifies the input (information) and requires feedback on what changes have been made by sampling the way the output was received. (S)he can then ensure that any changes were appropriate or interpreted in the way that they were intended.

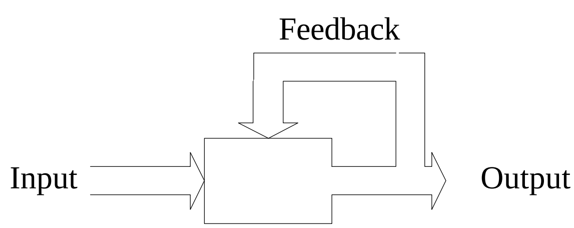


Figure 5. Feedback loop.

This is a highly constrained model when applied to human communications, but it is useful in thinking about the nature of feedback’s effect. The feedback path can be represented by Shannon and Weaver’s model in Figure 4 (Heinich, et. al, 1993; Littlejohn, 1978; Neulip, 1996; Shannon, & Weaver, 1971; Wagner, 1994) so as to visualize the many opportunities for noise to enter a system. This can be extended to the input and output channels as well.

Feedback can be regenerative as well as degenerative. Regenerative (or positive) feedback can cause the noise to feed on itself and, through iteration and regeneration, compromise an entire system. An example would be the acoustical feedback from a speaker through a microphone which causes a distinctively unpleasant sound. Degenerative (or negative) feedback attenuates noise. The model in Figure 5 is also extensible, so that the myriad modes of human communication (visual, physical, affective, etc.) can be represented as various feedback and noise elements that intersect and overlap. Personal meaning is somehow constructed out of this convoluted knot of information channels. SGS reduces the active exchange of information to a single pipeline therefore affecting communication by restriction and distortion. But like all bi-directional communication channels, an SGS provides a means of self-correction through feedback.

"Human communication will almost always go astray unless real energy is expended" (Reddy, 1982, p. 295). Therefore, <u>if</u>:

- the energy should be in the form of feedback
- feedback is a critical element in the educational experience (Travers, 1977)
- performance and/or competency can be improved through confirmation and/or correction of the student's conceptions (Gagné, Briggs, & Wager, 1988; Wagner, 1994)

<u>then</u> a dynamic system is required. Further, this system should be synchronous in nature to provide for immediate feedback. The shorter the delay, the greater the chance to inhibit misconceptions from entering long term memory and habit. Also, the sender needs to know if the message s/he is sending is getting through in the way s/he intended. If it is, then by viewing the same information and seeing/hearing the reactions/responses to that information, adjustments can be made to eliminate points of contention.

The behaviorist view is that feedback serves as reinforcement; whereas, the cognitivist view is that feedback eliminates errors in conceptualization (Mory, 1996). Shen (1991), in a literature review of feedback, finds a number of conflicting views on the timing and effectiveness of feedback. But in general, Wagner's (1994) statement that "Shen's review of feedback literature indicates that 'feedback as information' tends to be more effective than 'feedback as reinforcement' in response and concept learning" (p. 15) holds true. Feedback needs to be more than "right" or "wrong" for a person to correct him or herself. It needs to be informative if it is to be accurately applied. It also needs to be concurrent rather than terminal since one can forget "what there was to correct" (Travers, 1977, p.46).

An example of a more complex system incorporating feedback is the Schramm model (Schramm, 1954), also referred to as the Shannon-Schramm Communication Model (Henrich et al., 1993; Wagner, 1994) in Figure 6.

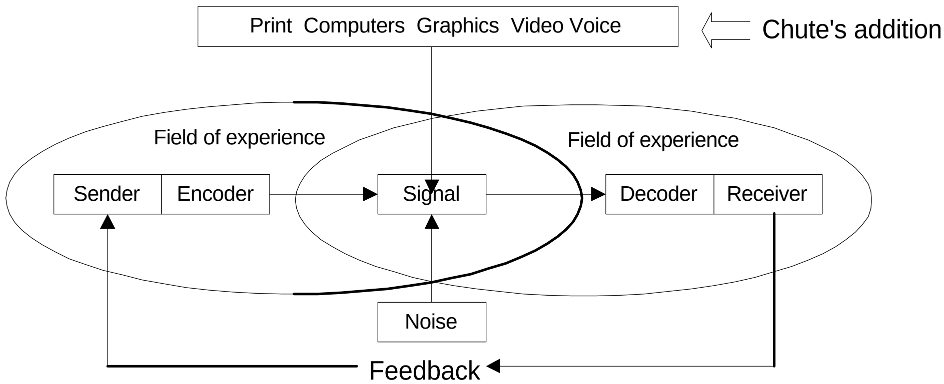


Figure 6. The Shannon-Schramm communication model.

Chute (in Wagner, 1994, p. 23) adapts this model to take into account the effects of media as a source of information. Chute does not take into account the filtering effect of the person interacting with the media, but apparently he is dealing with attributes inherent to the media and how they affect information. The effects of media on communication are largely ignored in these models. But once again, all of the components and channels can be intellectually reduced to the previous models. What is left out and what is the effect of separating information into different channels is largely ignored. By viewing a given communication (media) channel as a semi-permeable membrane, we can model how some, not all, information is permitted to pass through.

The ability to give feedback in an SGS to correct misconceptions and elicit growth requires a person. The Socratic method is an example of feedback in an instructional mode. Responses to questions provide information that is used to form subsequent questions. This question/response process is a continually evolving feedback loop. If a computer were capable of this form of interaction, a facilitator or instructor would not have to be available for synchronous interaction.

Turing (1950) devised a test which is widely recognized as a standard to judge whether a machine may be said to think. This test can be used as an accepted guide to computer/person communication. A computer passes the Turing test when a “questioner” communicating with text cannot tell if they are communicating with a machine or a person. An assumption is that a machine that could pass the test could be modified to ask questions and might be able to sustain a Socratic dialogue. However, even when a computer does pass the test, the computer responds in text. It is also doubtful that a computer that passes the Turing test will be able to deal with a graphic exchange any time soon, let alone probe for inconsistencies and weaknesses in a non-predetermined way. Note that a program called ELIZA, written by Joseph Weizenbaum could ask questions (Gardner, 1985) but could not pass the Turing test. It therefore appears that a person is necessary for interaction using an SGS.

A difficulty comes in assessing distance learning in a meaningful way. In a dynamic exchange between instructor and student, the instructor can probe thought processes and adapt to a student's level of expertise on the fly. Feedback (answers) from the student can determine the instructor's next question. A problem in face-to-face communication is that the student can obtain non-verbal cues from the instructor and use that form of feedback in adapting his/her answers. Therefore, the student appears to know more than they, in fact, know. Conversely, the student may be intimidated into revealing less than what he or she is capable of doing. In tutorial and drill software, the feedback is predetermined and usually based on set answers. A computer can only assess what it has been programmed to expect, and multiple choice or essays are static assessments of an activity. Without a dynamic exchange, little occurs to support a conversational, let alone teachable, moment.

We have to accept that there will always be some "noise" in any system and trust feedback to compensate for it. The trick is for the feedback to be as transparent as possible in order to reduce its own inherent noise. By incorporating graphics into the communication process, new types of noise might be generated, but the interactivity of the SGS should attenuate it. Consider bandwidth as a range of possibilities for communication. An increase in the number of possibilities could lead to confusion and a "Tower of Babel" or to greater opportunities for clarity. The noise generated by miscommunication can be reduced by making opportunities for feedback more robust, immediate, and appropriate for what is communicated. The graphics and synchronous interactivity of an SGS expands the communication bandwidth over the use of text and/or audio.

Mory (1996) sums up his section on Feedback Research in the <u>Handbook of Research for Educational Communications Technology</u> with "[W]hat we do know is that feedback serves a critical function in knowledge acquisition, regardless of the particular learning paradigm we are choosing to examine it through" (p. 951), but, "... feedback is of limited value when the final performance ... exclude[s] it" (in Travers, 1977, p. 47).

Learning

Clark (1991, 1994) continually points out that there is no significant difference in effectiveness between different media types. Even though students continually espouse a preference for a live instructor, there is no discernible benefit to supplying that live instructor (Barry & Runyan, 1995). By improving the communication space between a teacher and student, it might be possible to offset this preference. Otherwise, it is not worth the effort for teachers and students to use an SGS if it does nothing to enhance the learning process over the tools presently available. The SGS can be thought of as an affordance (Gibson, 1977), something that helps to make activities possible but not inevitable (CTGV, 1993). An SGS is more than a one-way presentation medium; it can increase the communication bandwidth through the addition of a graphics channel. It is then left to show how an SGS can affect the learning process through enhancement of the communication environment.

An approach used to show how an SGS affects the learning process is to start within the student and then progress through the student's interaction within an SGS and the way they develop context and apply what they have learned. This is accomplished by relating the student’s zone of proximal development to scaffolding used for apprenticeship (Brown & Palincsar, 1989).

Zone of Proximal Development and Communication

Vygotsky’s zone of proximal development (ZPD) (Vygotsky, 1978) is the area in which one can expand one’s learning with appropriate assistance. Vygotsky’s original description was that “[I]t is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (p. 86). It is more popularly considered as the area between the real and the potential (Blanck, 1990; Brown & Palincsar, 1989). This assistance can come from most anywhere and through any means, but it is generally social in nature. It is an active engagement between teacher and student or between peers (Diaz, Neal & Amaya-Williams, 1990). The implication for taking advantage of this space through the use of an SGS is that a learner must communicate and receive feedback to expand his/her present knowledge. The student not only adds to his/her present knowledge (which in the trivial sense can be accomplished through rote memorization) but does so in an active social context. How far a student can go at a given point in time is within the limit of his or her ZPD. This makes the ZPD time and communication dependent. This also implies a certain degree of synchronicity with an appropriate channel for communication.

Heinich, Molenda, and Russell (1993) take the idea of a ZPD and state that in the zone, “messages go beyond communication into learning” (p. 9). For the SGS to be a worthwhile tool for education it must facilitate the transcendence of messages into learning experiences.

Schramm (1954) states in reference to the fields of experience in Figure 6, “[T]hink of those circles as the accumulated experience of the two individuals trying to communicate. The sender can encode or the receiver can decode only in terms of the experience he has had” (p. 116). Even though they are from different theoretical bases, it is not a great leap to see the connection between Schramm’s model and the ZPD for two individuals learning from each other.

Ann Brown (1994) writes about a community of learners (COL) having multiple zones of proximal development that take advantage of “… people, tools, and powerful artifacts - tools and aids to perfect mind...” (p. 7). Keller and Sherman (1974) write “... the relation of the student to his tools, not just the improved design of the instruments, is what ultimately determines educational effectiveness” (p. 2). In attempting, at a distance, to engage learners in order to maximize their development, an SGS is a tool that expands the communicative space for collaboration. By empowering students with alternatives to text and audio, the “relation” of a student to his/her communication tools should “improve.” Therefore, increasing electronic communication options can help create COLs that are independent of place.

“Just in Time” Scaffolding

Scaffolding (Brown & Palincsar, 1989; Rogoff & Gardner, 1984) relates to ZPD in that appropriate support is made available as the student’s needs develop. A primary use of an SGS for scaffolding is to supplement a student’s verbal skills with visual alternatives. Another important aspect for scaffolding in distance learning is its relevance to the principle of “just in time”(JIT). JIT is an industry practice for inventory maintenance where only what is required for immediate production is made available. This results in reduced overhead. JIT, when applied to training, is a model for only providing assistance as it is needed. This cuts down on unnecessary training or training that will be forgotten by the time it is needed. It provides a model for making resources and scaffolding available instead of attempting to cover everything that might be needed (CTGV, 1993). By pre-deciding what might be needed and presenting it as “the body of knowledge,” the solution space for problem solving is constrained and the previously discussed beneficial noise is unheard.

Summary

The literature review started with the practical software and hardware considerations in employing an SGS for communications. The SGS was shown to overcome deficiencies in present forms of CMC by affording (Gibson, 1977) interactive communications with graphics. Because it coexists with other forms of CMC it maintains the advantages found in text, audio, and video based communications.

The dearth in literature supporting the use of an SGS for educational purposes necessitated relating literature on communications and education to warrant an initial study. The visual nature of the SGS (Dwyer, 1978; Levie, 1978; Park & Hopkins, 1973; Shepard, 1967) and its relevance in multi-channel communication (Dwyer, 1978; Hartman, 1961b; Hsia, 1968; Miller, 1956; Simon, 1974) were tied to the DCT (Paivio, 1979). The possible effect of an SGS, as a media form, on learning was related to its effect on mental effort (Britton et al., 1978; Salomon, 1981, 1983, 1994) and its attributes (Clark & Salomon, 1986).

Communication models (Heinich et al., 1993; Littlejohn, 1978; Neulip, 1996; Schramm, 1954; Shannon, & Weaver, 1971; Wagner, 1994) for considering the effects of feedback and noise (see Figures 4, 5, & 6) were presented as a foundation for considering the SGS as a communications channel in its own right. These models also give a perspective for evaluating an SGS’s contributions to communication in general and interactions with other forms of communications in particular. The concepts of noise (Brown et al., 1989; Neulip, 1996; Reddy, 1982; Wagner, 1994), and feedback (Gagné et al.,1988; Mory, 1996; Reddy, 1982; Schramm, 1954; Travers, 1977; Wagner, 1994) were related to aspects and usage of an SGS.

The view of an SGS as a communications channel was then tied to ZPD (Blanck, 1990; Brown & Palincsar, 1989; Diaz et al., 1990; Schramm, 1954; Vygotsky, 1978), and JIT for scaffolding (Brown & Palincsar, 1989; CTGV, 1993; Rogoff & Gardner, 1984). An SGS can be used to provide scaffolding and guidance as a student’s development warrants it. As a student progresses, the amount of support is withdrawn (faded) (Diaz et al., 1990). The student has access to a space where scenarios can be developed and solution paths explored visually, without the structural and semantic limitations that text demands.

Depending on the discipline, an SGS can greatly assist in collaboration by easing the presentation of concepts between students who are just beginning to grapple with the details. As a cognitive tool, an SGS allows visual manipulation of student ideas between students as well as with the instructor in a dynamic environment. If a shared graphic space is awkward to use, we have accomplished nothing, and may further discourage those already intimidated by course content from experiencing alternative learning environments.

Chapter 2
Methodology

The Research Problem

The term shared graphic space (SGS) refers to the interactive aspects of whiteboard software used for communications. Because this environment can contain graphics or text and can be supported by audio and/or video, the nature of its contribution to communication is difficult to isolate. This raises issues as to the nature of the feedback and noise in computer mediated communications when an SGS is introduced. In order to analyze the actions and isolate the modes of interaction, a post-positivist approach (Guba & Lincoln, 1994) was used. The post-positive approach allows for individual descriptions (qualitative) of identified feedback and noise supported through quantitative procedures. This quantitative /qualitative mode of inquiry is necessary to isolate and identify the characteristics of the feedback within the graphic space, if indeed their existence can be noted at all. Any identified characteristics and artifacts can then be used for comparisons across groups of subjects to see if there exists some common ground. This study assumes that there are some universal (objective) aspects of communication that can be identified. But these aspects can only be approximately labeled, not narrowly defined. It is not necessarily a matter of how many keystrokes, graphics, or words are used, as much as how and in what way they are used.

The epistemology of this study's approach is consistent with Guba and Lincoln (1994) since the identification of what constitutes occurrences of feedback and noise are interpretive. There is no perfect metric, only consensus that identifies feedback and noise occurrences. Since "[N]o study conforms exactly to a standard methodology," the methodology must be bent to the circumstances of the study (Miles & Huberman, 1994, p. 5). Therefore, by making a post-positive, descriptive study of communicants, it may be possible to identify and describe the characteristics of an SGS.

<u>Research Questions</u>

The research questions are:

- What is the nature of the communication events in the SGS?
- What is the nature of the feedback when communicating in a shared graphic space?
- What is the nature of the noise when communicating in a shared graphic space?

The first question provides an avenue for isolating any contribution of graphics to interactive communications. The second and third questions are descriptive in nature and are fundamental in understanding the SGS as a communicative tool. In order to isolate the feedback and noise that an SGS brings to CMC, several assumptions are made. The first assumption is that there are some interactions with the SGS that are common to text and audio. The second assumption is that the addition of audio for verbal communications will reduce the use of text in the SGS and the number of visual cues. If the participants refine or otherwise change their modes of communication while engaging in the SGS, then some form of learning through feedback may be revealed.

Research Design

Setting

The research activities were conducted in an office and computer server room on the second floor of War Memorial Hall at Virginia Polytechnic Institute and State University. The rooms are adjacent to computer labs and faculty offices. The rooms provided some privacy and isolation from normal lab activities. The participants were physically separated to prevent the introduction of physical cues (see Figure 7). They had access in each room to a computer, microphone, and a choice of a headset or speaker for communication. A description of their use is in the section on “Problem Solving Situations and Data Collection Procedures.”

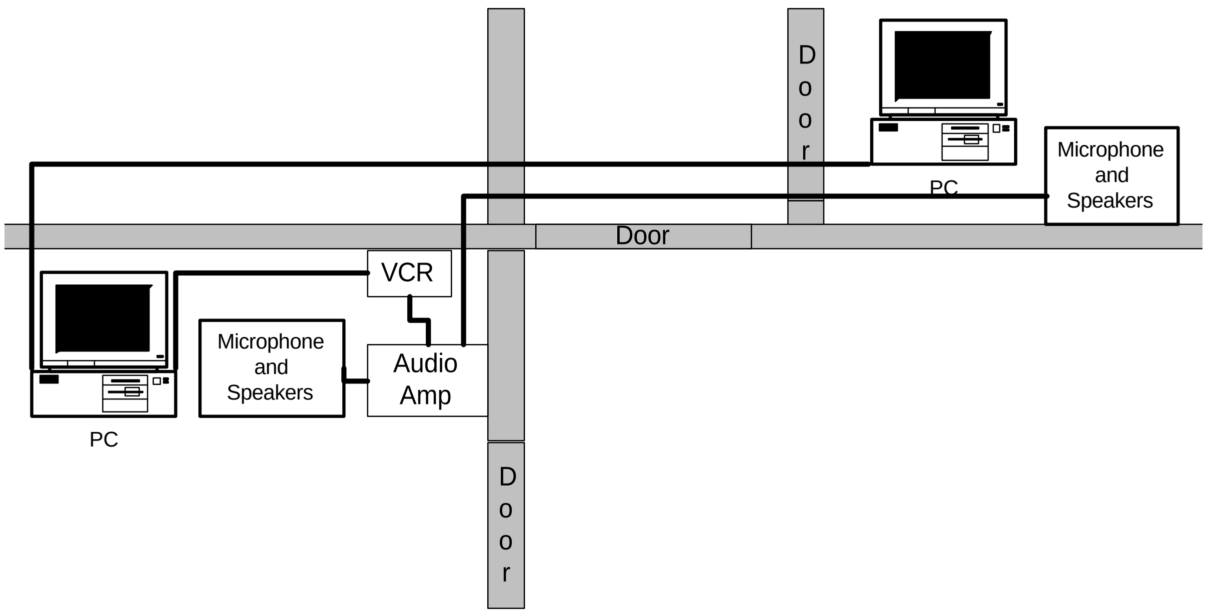


Figure 7. Computer hardware setup for the study.

Materials and Technologies Used

The whiteboard in Microsoft’s Netmeeting™ software was used on two PC clone computers. Audio exchange and recording was accomplished through a dedicated audio amplifier system. The system allowed recording of the participants interacting with each other as well as anything they said to themselves when the audio channel between them was turned off.

In order to introduce the participants to the whiteboard’s tools a short (5 minute) training videotape was constructed and utilized. The tape illustrated screen activity with an audio track to explain each whiteboard tool as it was used to create and edit a stick figure. All tools to be used were demonstrated and explained. The tools used were for object selection, text, freehand draw, straight line, filled and unfilled circle, filled and unfilled square, highlight, erase, zoom, pointer, and color selection. Several menu driven items were also covered: cut, copy, paste, delete, and undelete within the whiteboard application. Copy and paste from other applications/windows and screen locking were not used.

Video taping was accomplished with a scan converter to change a computer monitor signal to NTSC for recording on video tape. All computer display information was then recorded. Since both screens display identical information, only one was captured. Audio was captured through an audio amplifier to the VCR.

Participants

An SGS can be used by more than two people. But, because this was an initial study, it was confined to dyads since they are the lowest common denominator for interpersonal communication. An added benefit in restricting the study groups to dyads was that it simplified analysis by eliminating complex (triad or greater) group interactions.

The study began with nineteen dyads, for a total of thirty-eight participants. Three dyads (3, 4, and 11) were dropped from the study for technical failures with the software and problems with materials. The participants were selected from graduate students, undergraduate students, faculty and staff at Virginia Polytechnic Institute and State University. They were referred to the researcher by faculty and graduate students in the College of Human Resources and Education.

Computer experience (or lack of) was examined to see if it engendered unique ways of interacting. Skills were examined in order to isolate ways in which effective communication strategies were fostered or inhibited. Participants received a questionnaire that was used to assess levels of experience and isolate particular skills that could affect the use of an SGS (Appendix B). The questionnaire was based on a similar one used by the Media Services department at Virginia Polytechnic Institute and State University. The results of the questionnaire are in Tables K1, K2, and K3.

The size of the sample was such as to warrant some intervention consistent with sampling guidelines in Miles and Huberman's Qualitative Data Analysis (1994). A purposive sample for each dyad was used as participants were assigned times for their session. The sample size was small and the effects of experience, age, and acquaintanceship were unknown. To offset any interactions, it was decided to create a variety in experience, age, and acquaintanceship whenever possible.

Data Sources

The sources of data that were collected for this study were: videotaped interactions, field observations, and participant comments (written responses to pre- and post-session questionnaires, comments entered on the whiteboard, oral comments in a post session interview).

The primary sources of data were from the videotape of the participants' interactions in the whiteboard environment and in the separate audio channels that were mixed (combined) and recorded on the same videotape. Specifically, the uses of text, graphics, and audio were assessed for their contribution to communication. These interactions were examined as to whether they elicited or gave feedback. The interactions were also identified as to whether they interfered with, or were extraneous to, what was communicated (i.e., they were noise).

A secondary source of data was taken from post-session comments that were elicited by a request on the last slide on the whiteboard to document participant reactions as to limitations and advantages of this form of communication. This part of the post-session comments was recorded on the whiteboard with both participants writing comments.

A third source of data arose from field observations of the participants. The observations included whether the participants used the physical pieces, had problems that were not captured on the whiteboard, were aloof or engaged, etc. These observations assisted in framing questions for the participants' end of session interviews.

Exit interviews were also conducted to answer participant questions as well as bring up concerns raised by observations during that particular session. These interviews occurred immediately after the session so as not to influence the participants' performance.

Problem Solving Situations and Data Collection Procedures

The participants engaged in the following tasks. Each dyad

1. read and signed the human subjects informed consent form (Appendix A).
2. filled out a questionnaire to assess their experience (Appendix B).
3. watched a videotape which covered the whiteboard tools and menus.
4. were informed of the activities they would engage in and could ask questions.
5. were separated into different rooms.
6. worked through 12 whiteboard screens, the first four screens (Appendix G) repeated some of the directions they had been told, the second four screens were problems to solve, the next screen either permitted the dyad to start using audio or stopped it from using audio, the next two screens were problems to solve, and the last screen elicited comments.
7. filled out a post-session questionnaire (Appendix C).
8. were brought together for an exit interview.

The dyads were informed that there was no time limit for the activity. They were given no specific instructions on how to do the activity. They were only given the initial and final conditions and were informed that they could use any of the tools covered in the training video. There were two caveats. If they started with audio capabilities for communication, at some time during the activity a whiteboard screen would inform them that they could no longer use audio. If they started without audio, at some time during the activity a whiteboard screen would inform them that they could use audio for communication.

The Activity

The activities involved communicating the solution to a puzzle. The participants alternated as sources of information for the puzzle's solution in a manner described later in this section. The puzzle consists of the seven plastic pieces which are manufactured by Rex Games Inc. and sold as the game Tangoes ® (see Figure 8).

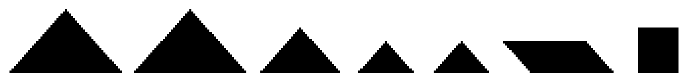


Figure 8. The puzzle shapes used in the study.

These pieces are used to construct complex shapes representing various geometric forms and representations (e. g., see Figure 9).

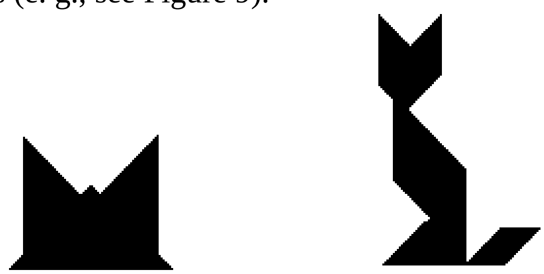


Figure 9. Puzzle examples.

The procedure for acquiring the data began immediately after the participants viewed the video training tape. Six activities were constrained according to two scenarios. In one scenario, the first four activities were limited to communicating with text and graphics only, and audio communication was permitted in the remaining two activities. In the other scenario, dyads were permitted to use audio for the first four sessions and then were limited to text and graphics for the remaining sessions. The chart in Table 1 illustrates the alternation of solutions (X) between participants A and B for the six activities. In session 1, participant A had the solution; in session 2, participant B had the solution, etc.

Table 1
Alternation of Solutions Between the Participants

	Session Numbers					
P	1	2	3	4	5	6
A	X		X		X	
B		X		X		X

Note. X represents that the (P)articipant (A or B) has the solution.

Each participant had a sheet of paper with three images and the tangram solutions (Figure 10). There was no break between the activities so that any evolution in communication was limited to the computer. As stated above, the activities involved each participant receiving a different card (see Figure 10) and physical geometric pieces (see Figure 8).

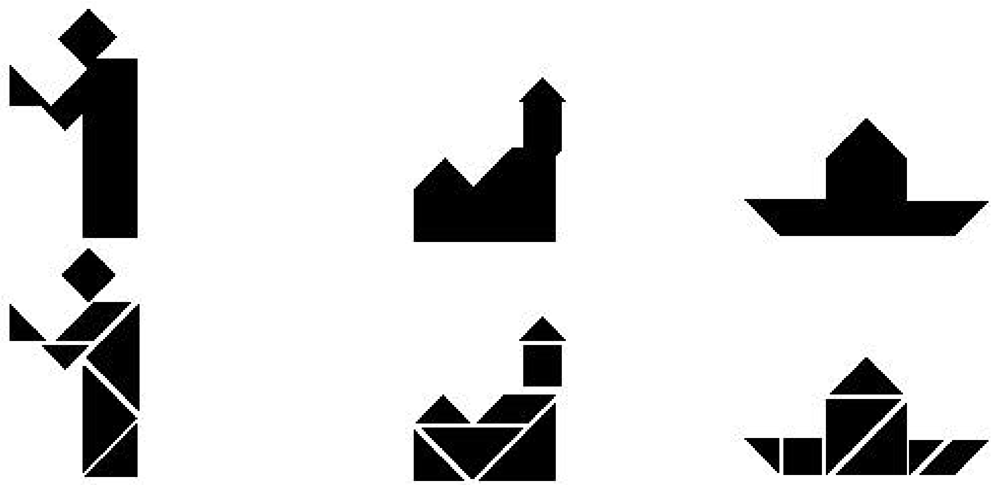


Figure 10. Puzzle examples with solutions.

The cards contained three puzzles and their solutions. When the participants could not use audio in the first four activities, they were constrained to graphics and text. These first four sessions allowed the participants to gain training in communicating in the graphic space before audio was introduced. Figure 11 shows an example of the computer screen that both participants saw. It contained a representation of a puzzle.

Figure 11. Screenshot of Netmeeting™.

As illustrated in Table 1, the order in which the puzzles were presented alternated the solutions between the participants. By using four trials, each participant received feedback as to his/her ability to communicate the solution and have some effect on the other participant's method of communicating through this iterative process. While this in no way made them experts, it did permit some increase in competency in using the tools involved. The other scenario that began with audio followed the same regimen.

The participants had plastic puzzle pieces for physical manipulation. Participants could use the pieces in any way they wished. For instance, a participant with the solution could verify whether what s/he was communicating in the SGS worked. A participant receiving the solution could use the pieces to assemble the solution in order to verify that they actually could solve the puzzle based on what was communicated to him or her.

The final two activities introduced audio into a previously visual-only communication environment (text and graphics). Otherwise, the activities were the same as the previous four. The participants were free to choose any manner or combination of text, audio, and graphics to communicate the solution. Again, the other scenario that began with audio followed the same regimen.

Rationale

The target task was oriented toward communicating a solution to a problem. By forcing participants to alternate roles of possessing some piece of "knowledge," all of the participants were placed in an active role. This active role placed the burden of communicating on each participant in turn. By alternating this role, participants chose to use, discard or modify techniques introduced by the previous active participant. The amount of divergence between participants can be seen as a form of feedback to each other as to what worked. A participant who would be denied this opportunity would not have a complete awareness of his or her own actions.

Only essential parts of the whiteboard's capabilities were introduced in order to reduce training time and simplify isolating communication attributes and strategies. Features such as cutting, pasting, and individual manipulation of screen objects were constrained to images and text directly entered into or already present in the SGS. Although "real world" usage includes the ability to incorporate information from other sources, the activity chosen to frame this study confined the participants to the whiteboard by including all relevant information on the whiteboard or in physical space. The activity introduced to frame the use of the graphic space could be accomplished without graphics. This allowed the possibility of choosing minimal interaction in the SGS. If the SGS is a valuable tool for communication, then it should be freely chosen among alternative methods. Conversely, by making the whiteboard the only "window" for communication, any associated communication artifacts are easier to isolate. A balance between alternative choices and the introduction of the SGS was accomplished via the design of the study.

Analysis Overview

The first step in the analysis process consisted of compiling the results of the pre- and post-session questionnaires (see Tables K1, K2, & K3 and Appendix D, respectively), and the final whiteboard screen which contained participant comments. The results of the questionnaires and comments were not analyzed as part of this study, but they were used to guide and support the analysis of the graphic interactions in the whiteboard. Since the dyads chose different strategies and tactics, their responses and comments could not be directly analyzed with respect to all dyads. The other comments were not acquired systematically with the intent to compare across all dyads. They were for clarification of the participants' actions during their individual sessions. A copy of the post-questionnaire and the responses are in Appendix C and D. Some comments come from interviews immediately after each session.

The second step was to review the videotapes and code the data with respect to the type and order of the interactions (graphics, text, audio), as well as break down the graphics into descriptive, action, or highlight sub-categories (to be defined later). The form used is found in Appendix E. The forms were photocopied, color coded, and taped together into a single, large table to assist in identifying patterns of interaction. The results are summarized in Tables H1, H2, and H3.

The third step was to breakdown the video into 10-second intervals according to the categories in the second step. The form used is in Appendix F. The data was then entered into a spreadsheet for analysis and charting. The results are summarized in Appendix H. Steps two and three categorized and reorganized the data for sequence and interval analysis.

The videotapes were also reviewed in a general manner in order to "get a feel" for individual and dyad-centric interactions. After all the data were compiled, the following questions guided the videotape analysis:

- What strategies did the participants employ?
- How did the participants communicate?
- How (if at all) did noise in communication occur?
- What did the sessions "look" like when viewed by event or change in interaction?
- What did the sessions "look" like when interactions were viewed with respect to time?
- How (if at all) did the introduction of audio change the nature of the communication?

Data Analysis

Huberman and Miles (1994) define data analysis as "... consisting of three concurrent flows of activity: data reduction, data display, and conclusion drawing/verification" (p. 10). These activities can occur, all or individually, before, during and after the data collection process.

The data were recorded according to whether they were descriptive (D), an action (Ac), a highlight (H), text (T), or audio (Au). Descriptive, action, and highlight refer to graphical events in the SGS. Descriptive events are drawings and representations. Action events are dynamic occurrences such as moving graphic elements or pointers as a way of illustrating an activity or to complement textual or audio references. Action events also include erasing elements and text blocks. Highlighting events included using pointers and arrows as static elements to draw attention, text labels for graphic elements, underlining, circling, and the use of the highlight tool. The examples below illustrate how the interactions were coded by category.

Descriptive (D) - any static use of graphics, i.e. drawing a shape

Action (Ac) - any dynamic use of graphics to draw attention to a **D**
  - moving a **D** to show where to place it
  - moving the pointer to draw attention even though the pointer is left somewhere on the whiteboard.
  - erasing.

Highlight (H) - any static enhancement of a **D**
  - use of pointer without motion in order to draw attention.
  - drawing an arrow.
  - underlining.
  - circling a **D.**
  - using the highlighting tool.
  - labeling with text.

Text (T) - any use of text except for labeling
  - either typed or freehand with a drawing tool

Audio (Au) - any use of audio

The compiled data were then color coded and strip charts were created for the interaction-based analysis. The time-block based analysis was entered into a spreadsheet and converted to a color coded chart for pattern analysis.

A starting point for analyzing the time-based data consisted of the chart in Appendix F where the data was coded in 10-second blocks. Each column in the chart represents a 10-second interval. There are two sets of rows, one for participant A and one for participant B. Each set of rows consists of five categories which are described later in this section. If an event listed in one of the rows occurred, a checkmark would be entered. A category would be checked only once per interval. A timer would beep every 10 seconds to alert the observer to change columns. The charts were taped into strips and the events color coded for a visual check for pattern analysis. The data was then placed into a spreadsheet with each checkmark entered as a 1. An excerpt from the resulting chart (see Figure 12), illustrates a typical audio/descriptive graphic sequence from dyad 9. The rows represent 10-second intervals. There are 5 columns for each dyad participant. A “1” in a cell indicates that one or more of the events at the top of the column had occurred during interval represented by the row. The first row contains no 1s, therefore, no event had taken place. The second row contains a 1 in the descriptive columns and in the audio columns for participants A9 and B9. Both participants drew and spoke in that interval. In the third row only B9 drew or spoke.

Deficiencies in this form of data organization are the order and amount of interaction. In a 10-second interval, descriptive and audio events may occur, but the number and sequence are not revealed. Examples of several possible combinations of events for B9 in row 3 of Figure 12 can be:

- a descriptive event followed by an audio event.
- an audio event followed by a descriptive event
- a descriptive event followed by an audio event followed by another descriptive event.
- a descriptive event concurrent with audio and followed by another descriptive event.

These were just a few of the possibilities for a single participant. That is the reason for also compiling the data according to the sequence and number of events or interactions.

A9					B9				
Descriptive	Action	Highlight	Text	Audio	Descriptive	Action	Highlight	Text	Audio
1				1	1				1
					1				1
					1				1
				1					1
				1					1
1				1	1				1
1				1					1
1				1					1
				1					1
1				1					1
1				1					1
1				1					1
1				1					1
1				1					1
				1					1

Figure 12. A typical audio and graphics sequence.

Data from the videotaped whiteboard sessions were entered into charts based on interactions as well as time. This is in contrast to the interaction charts (Appendix E) where an event was recorded whenever the type of interaction changed. For instance, if participant A was typing and then participant B drew something while A was typing, this would be recorded as two events. The same events when recorded in time blocks would appear to occur simultaneously (see Figure 13). Ten-second blocks were arrived at through trial and error as the shortest interval in which data could be comfortably viewed and recorded. There are two participants with up to five events each for ten individual or simultaneous entries. The activity in the SGS can occur quickly and in several different places simultaneously. This made it difficult to assess separate events.

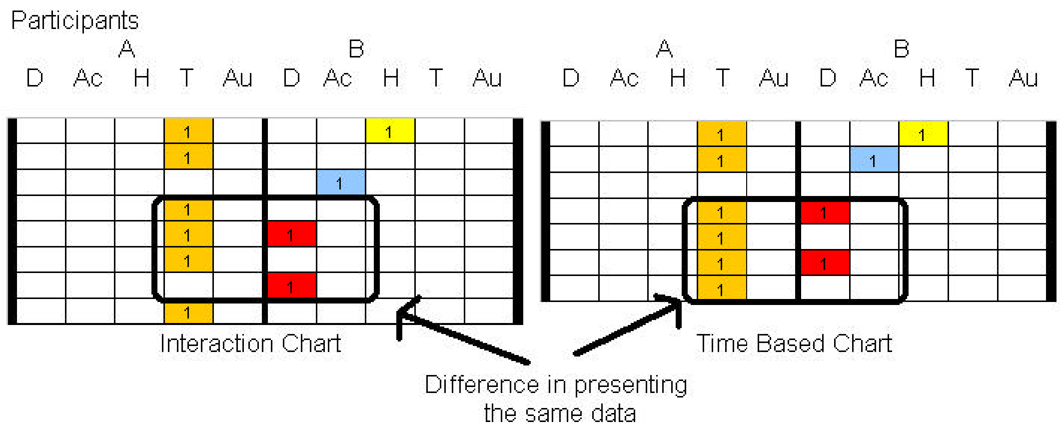


Figure 13. Comparison of different means of organizing events in an SGS.

As Patton (1990) points out, a matrix can put an analyst in the position of forcing the data to fit the matrix: "Logical analysis to generate new sensitizing concepts must be tested out and confirmed by the actual data" (Patton, 1990, p. 412). If these codes proved to be too broad or otherwise inadequate, they would need to be redefined or discarded as the data were analyzed (Miles & Huberman, 1994). For this study, the data ultimately dictated the categories and analysis techniques.

Investigator

The investigator of this study had a role of a non-participatory observer. His viewpoint is from a technical background which assumes mechanistic cause and effect relationships. His viewpoint is nominally a positivist stance although the method of analysis in this study is postpositivist.

The investigator comes to this study from a community college teaching background (Assistant Professor in Electronics) which placed heavy emphasis on the use of visual information. It was this background that supplied the impetus to this inquiry. Which creates a bias toward visual communication and the identification of feedback and noise as components of communications.

The investigator has spent the past year working with conferencing software in order to assess its educational value. He conducted a pilot study to evaluate the method of data acquisition proposed for this study. The pilot study participants were colleagues and friends with mixed backgrounds. The pilot study adhered to the procedures in the previous section and were adjusted according to comments and discussions with the participants. The final study procedures are based on the pilot study iterations. See Appendix I for the pilot study summary.

Chapter 3
Results

Organization of Results

The first section of this chapter deals with quantitative aspects of the study, what the descriptive statistics tell us about the participants, the dyads, and the interactions. The second section is descriptive of the participants' actions and interactions. This section begins with identifying interactions that can be considered noise in the SGS, and then closes with the methods of feedback in the SGS. The final section sums up what was discovered in light of the interactions.

The convention used to identify participants in the tables is to list the participant letter, A or B, followed by the dyad number. A and B refer to a participant where A was always the first person possessing a solution for the six activities. For discussion purposes the participants in this study are referred to as AX and BX. X refers to the dyad number. Therefore B12 is participant B in dyad 12. This format is used to increase readability for intra-dyad discussions. References for inter-dyad discussions will refer to dyad 1, dyad 2, etc.

Quantitative Aspects of the Interactions in the SGS

General Overview

The purpose of this study was to assess the unique contributions of graphics as a communication channel in an SGS. To reiterate the research questions:

- What is the nature of the communication events in the SGS?
- What is the nature of the feedback when communicating in a shared graphic space?
- What is the nature of the noise when communicating in a shared graphic space?

Each of the dyads approached the SGS and the framing activity differently. While this inhibits direct comparison of activities it does not stop one from comparing the style and types of interaction used to communicate. And in spite of these differences, some time-based analyses reveal patterns within and between dyads. This section begins with a look at the numbers and then proceeds to expand on several aspects under the headings:

- Audio versus Text
- The Role of Graphics
- Time Percentages Across Dyads
- Interaction versus Time
- Physical Pieces

There were 38 participants in 19 dyads. 3 dyads were excluded from the final analysis due to technical failures. This left 32 participants in 16 dyads. The dyads remaining were: 1, 2, 5, 6, 7, 8, 9, 10, 12, 13,14, 15, 16, 17, 18, and 19. Eight dyads started with audio capabilities for the first four activities and eight dyads had audio capabilities introduced for the last two activities only.

Table H1 displays the results of the pre-session self-assessment questionnaire (Appendix B) for expertise in software related to whiteboards, graphics, and communication. The ratings were on a 7-point scale. The mean familiarities for the audio first and audio introduced later were 4.3 and 4.0 respectively. The audio first group had a greater deviation. By eliminating dyad 6 the standard deviation (SD) changed by 33% from 1.5 to 1.0. As will be discussed later, dyad 6 had some unique problems. The overall familiarity columns in Tables K1, K2, and K3 are from the first question on the self-assessment questionnaires asked the participants to rate their overall software familiarity. This number was not used for any other calculations, but was compared to the mean of the other software scores. The overall familiarity score was greater than the mean of the other software scores for 31 of the participants. The exception was participant A in dyad 18 who had a mean software score of 5.29 compared to an overall familiarity score of 5. Sixteen of the participants had overall familiarity scores within one unit of measurement over their computed software score means. The remaining 14 were up to 2.6 units of measurement (participant B in dyad 17) over their computed software score means.

The participants had access to plastic pieces that could be used to solve the puzzle, verify their perceptions of what they were communicating, or used in some other manner. Table 2 contains data on whether participants used the pieces to solve or verify what they were communicating when they were in possession of the solution.

Table 2
Participant Use of Puzzle Pieces

Dyad		Participant A	Participant B
1		P	
2			
5		P	P/V
6	A	P	P
7		P	
8	A	P	P
9	A	P	P/V
10	A	P/V	P/V
12	A	P	P/V
13			
14		P/V	P/V
15		P/V	P/V
16	A	P/V	P/V
17		P	P/V
18	A	P	P
19	A	P/V	P/V

Note. P = participant used the puzzle pieces; V = the participant verified what they were communicating by manipulating the puzzle pieces; A = audio was used for the first four activities

Data Organized by Intervals and Interactions

Comparing the number of events per 10-second interval in Table H4 to the number of interactions in Table H5 reveals a mismatch. Although the categories are the same, the comparison of time to interaction brings forward the issues discussed earlier with reference to Figure 12. An interaction can overlap several 10-second time blocks or several interactions can occur within a single time block.

The number of descriptive events, action events, and highlight events are more numerous in audio first dyads. This is shown when the number of events are broken down into "audio initially present" in Table 3 and "audio not initially present" in Table 4.

Table 3
Number of Events According to 10-Second Intervals when Audio Is Initially Present

	Descriptive		Action		Highlight		Text		Audio	
Dyad	A	B	A	B	A	B	A	B	A	B
6	67	49	10	11	4	0	7	4	96	102
8	65	40	16	21	6	3	0	3	119	102
9	23	15	0	3	0	2	5	4	36	39
10	88	70	23	26	5	12	40	28	223	211
12	81	42	38	20	8	12	22	12	174	150
16	29	14	4	6	4	2	1	2	89	96
18	22	25	7	5	18	20	9	14	77	76
19	27	25	7	6	2	11	11	6	80	77
Subtotal	402	280	105	98	47	62	95	73	894	853
Total	682		203		109		168		1,747	

Note. Column headings A and B refer to participants A and B.

Table 4
Number of Events According to 10-Second Intervals when Audio Is Not Initially Present

	Descriptive		Action		Highlight		Text		Audio	
Dyad	A	B	A	B	A	B	A	B	A	B
1	33	26	10	0	4	0	35	16	6	10
2	69	74	36	41	14	20	99	81	37	17
5	25	24	6	3	0	2	65	33	28	28
7	87	28	5	5	0	1	11	22	18	20
13	43	30	16	9	5	2	44	39	36	40
14	24	3	4	3	3	0	34	33	19	19
15	33	23	4	2	6	9	31	23	23	25
17	34	22	1	2	7	16	10	14	20	26
Subtotal	348	230	82	65	39	50	329	261	187	185
Total	578		147		89		590		372	

Note. Column headings A and B refer to participants A and B

The total time spent on the 6 activities ranged from 611 seconds to 4,529 seconds (see Table 5). The time in Table 5 for all groups, and Tables 6 and 7 for audio introduced later and initially groups, have columns for the time spent on activities 1 and 2, 3 and 4, 5 and 6, total time for all 6 activities and the percent of total time spent on activities 3 and 4 and 5 and 6. This breakdown of time is based on grouping sets of communications with each participant having the solution given to them. The dyads using audio first spent less time on average (32 vs. 34%) on activities 3 and 4 and more time on average (22% vs. 20%) on activities 5 and 6 where they were denied audio and used text.

Table 5

Time Spent for Activities by Each Dyad

	Time taken by dyads for activities (sec.)					% of activity time	
Dyad	1-6 (All)	1-2	3-4	1-4	5-6	3-4 to 1-6	5-6 to 1-6
1	1,549	668	495	1,163	386	32%	25%
2	4,529	1,894	2,225	4,119	410	49%	9%
5	1,541	732	497	1,229	312	32%	20%
6	2,837	1,700	670	2,370	467	24%	16%
7	1,389	580	505	1,085	304	36%	22%
8	2,364	1,718	364	2,082	282	15%	12%
9	611	232	196	428	183	32%	30%
10	3,745	894	1,374	2,268	1,477	37%	39%
12	3,097	838	1,333	2,171	926	43%	30%
13	1,780	734	629	1,363	417	35%	23%
14	1,216	717	300	1,017	199	25%	16%
15	1,405	672	482	1,154	251	34%	18%
16	1,442	890	341	1,231	211	24%	15%
17	1,338	609	415	1,024	314	31%	23%
18	1,258	449	414	863	395	33%	31%
19	1,265	648	301	949	316	24%	25%
Total time	31,361				*M*	32%	22%
M	1,960						

Table 6

Time Spent per Activity by Each Dyad When Audio Was Introduced Later

	Time taken by dyads for activities (sec.)					% of activity time	
Dyad	1-6 (All)	1-2	3-4	1-4	5-6	3-4 to 1-6	5-6 to 1-6
1	1,549	668	495	1,163	386	32%	25%
2	4,529	1,894	2,225	4,119	410	49%	9%
5	1,541	732	497	1,229	312	32%	20%
7	1,389	580	505	1,085	304	36%	22%
13	1,780	734	629	1,363	417	35%	23%
14	1,216	717	300	1,017	199	25%	16%
15	1,405	672	482	1,154	251	34%	18%
17	1,338	609	415	1,024	314	31%	23%
Total time	14,742				*M*	34%	20%
M	1,843						

Table 7
Time Spent per Activity by Each Dyad When Audio Was Initially Present

	Time taken by dyads for activities (sec.)					% of activity time	
Dyad	1-6 (All)	1-2	3-4	1-4	5-6	3-4 to 1-6	5-6 to 1-6
6	2,837	1,700	670	2,370	467	24%	16%
8	2,364	1,718	364	2,082	282	15%	12%
9	611	232	196	428	183	32%	30%
10	3,745	894	1,374	2,268	1,477	37%	39%
12	3,097	838	1,333	2,171	926	43%	30%
16	1,442	890	341	1,231	211	24%	15%
18	1,258	449	414	863	395	33%	31%
19	1,265	648	301	949	316	24%	25%
Total time	16,614				*M*	32%	22%
M	2,077						

Based on the data from the time period events, 26 participants used graphics (the sum of all descriptive, action, and highlight events) in fewer intervals than text and audio combined (see Tables 8, 9, and 12). Six participants (A1, B2, A7, and A17) used graphics in more intervals than text and audio combined and 2 participants (A2 and B17) used graphics in the same amount of intervals. Those 8 participants all had audio introduced later.

The dyads who had audio introduced initially had a total of 1,915 intervals of communication containing text or audio (combined totals), compared to 994 intervals containing graphics (see Table 8). From an interaction standpoint, the dyads with audio introduced initially, had 2,181 interactions with text or audio (combined totals), compared to 1,050 interactions with graphics (see Table 9).

Table 8

Graphics, Text, and Audio Events When Audio Was Initially Present

	Graphics		Text and Audio	
Dyad	A	B	A	B
6	81	60	103	106
8	87	64	119	105
9	23	20	41	43
10	116	108	263	239
12	127	74	196	162
16	37	22	90	98
18	47	50	86	90
19	36	42	91	83
Subtotal	554	440	989	926
Total	994		1,915	

Note. Column headings A and B refer to participants A and B.

Table 9

Number and Kinds of Interactions When Audio Was Initially Present

						Total						
Participant	D	Ac	H	T	Au	D	Ac	H	T	Au	I	Time
A6	48	10	0	6	86							
B6	29	7	0	2	91	77	17	0	8	177	279	2,900
A8	86	16	9	1	110							
B8	40	21	14	1	103	126	37	23	2	213	401	2,400
A9	36	0	1	4	39							
B9	18	2	0	4	42	54	2	1	8	81	146	600
A10	98	27	4	19	353							
B10	73	24	11	22	348	171	51	15	41	701	979	3,800
A12	91	38	21	14	185							
B12	39	8	15	8	178	130	46	36	22	363	597	3,200
A16	38	5	0	1	109							
B16	11	6	4	3	97	49	11	4	4	206	274	1,600
A18	38	6	18	9	108							
B18	32	11	19	10	98	70	17	37	19	206	349	1,300
A19	25	9	3	5	55							
B19	19	7	13	8	62	44	16	16	13	117	206	1,300
					Total	721	197	132	117	2,064	3,231	
						Graphics Total		1,050	T&A Total	2,181		

Note. D= descriptive events; Ac = active events; H = static highlight events; T = text was entered; Au = audio was used; I = interactions; time is in seconds.

The dyads who did not have audio introduced initially had a total of 948 intervals of communication containing text or audio (combined totals), compared to 876 intervals containing graphics (see Table 10). From an interaction standpoint, the dyads who did not have audio introduced initially, had 756 interactions with text or audio (combined totals), compared to 568 interactions with graphics (see Table 12).

Table 10
Graphics, Text, and Audio Events When Audio Was Not Initially Present

	Graphics		Text and Audio	
Dyad	A	B	A	B
1	47	26	41	26
2	119	135	136	98
5	31	29	93	61
7	92	34	29	42
13	64	41	80	79
14	31	6	53	52
15	43	34	54	48
17	42	40	30	40
Subtotal	469	407	516	432
Total	876		948	

Note. Column headings A and B refer to participants A and B.

Table 11
Number of Interactions When Audio Was Not Initially Present

						Total						
Participant	D	Ac	H	T	Au	D	Ac	H	T	Au	I	Time
A1	8	9	2	12	9							
B1	12	1	1	8	10	20	10	3	20	19	72	1,600
A2	49	31	8	46	23							
B2	37	38	13	34	15	86	69	21	80	38	294	4,700
A5	19	3	0	50	26							
B5	28	7	1	35	27	47	10	1	85	53	196	1,600
A7	39	6	0	5	28							
B7	21	2	1	11	27	60	8	1	16	55	140	1,500
A13	39	13	4	30	44							
B13	14	0	3	31	46	53	13	7	61	90	224	1,800
A14	18	4	1	20	31							
B14	5	6	0	22	29	23	10	1	42	60	136	1,200
A15	25	5	0	18	29							
B15	20	2	15	9	28	45	7	15	27	57	151	1,500
A17	19	1	4	6	17							
B17	13	2	19	10	20	32	3	23	16	37	111	1,400
					Total	366	130	72	347	409	1,324	
						Graphics Total		568	T&A Total	756		

Note. D= descriptive events; Ac = active events; H = static highlight events; T = text was entered; Au = audio was used; I = interactions; time is in seconds.

The totals for all dyads were 2,877 intervals of communication containing text or audio (combined totals), compared to 1,808 intervals containing graphics in Table 12. From an interaction standpoint, the totals for all dyads were 2,937 interactions with text or audio (combined totals), compared to 1,618 interactions with graphics (see Table H5).

Table 12
Graphics, Text, and Audio Events

Dyad	Graphics A	Graphics B	Text and Audio A	Text and Audio B
1	47	26	41	26
2	119	135	136	98
5	31	29	93	61
6	81	60	103	106
7	92	34	29	42
8	87	64	119	105
9	23	20	41	43
10	116	108	263	239
12	127	74	196	162
13	64	41	80	79
14	31	6	53	52
15	43	34	54	48
16	37	22	90	98
17	42	40	30	40
18	47	50	86	90
19	36	42	91	83
Subtotal	1023	785	1505	1372
Total	1808		2877	

Note. Column headings A and B refer to participants A and B.

Table H6 breaks the action and highlight categories, which are non-descriptive uses of graphics, into 9 particular sub-categories:

Pointer -the active or static use of the hand pointer tool
Outline -moving the hand pointer in order to trace an outline of a shape
Arrow -drawing an arrow or mark to draw attention to some feature of a graphic
Circle -drawing a circle, box, etc. around a part or whole descriptive image
Erase -erasing or cutting all or part of a graphic or text block
Undelete -restoring or pasting a graphic or text block
Move -moving all or part of a graphic or text block
Label -using typed or freehand text to identify all or part of a graphic

Highlight -using the highlight tool

The most frequently performed action or highlight was to erase. It occurred in all groups a total of 248 times out of a total of 562 action and highlight interactions combined. The next most frequently used action or highlight was the hand pointer with 132 occurrences, followed by labeling with 51 occurrences and drawing an arrow or mark with 48 occurrences.

Twelve dyads had a higher percentage of action interactions over combined action and highlight interactions (see Table H7). They ranged from 54.5% (dyad 13) to 100% (dyad 6). The remainder ranged from 12.5% (dyad 17) to 50% (dyad 19).

Audio versus Text

It was assumed that the addition of an audio communication channel would override the use of text. This was clearly the case for all the dyads. With the exception of text as a labeling mechanism for puzzle pieces on the screen (see Figure 14), only dyads 10 and 19 used text when audio was present. Exceptions were B10, who used the freehand drawing tool for humor and B19 who used text instead of audio to practice communicating when audio would no longer be present.

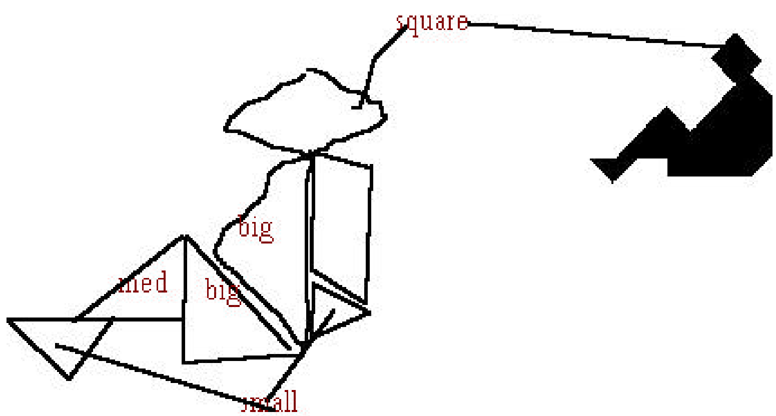


Figure 14. The use of text labels.

Table H4 breaks down the number of 10-second intervals in which descriptive, action, highlight, text, and audio events occurred according to individual participant and as a total for all dyads. Table 12 combines all graphic, text, and audio events (interactions) according to dyad and then compares total graphics events to combined text and audio. The numbers confirm what visual analysis of the charts suggests; audio is the dominant mode of communication. Tables 3 and 4 breakdown the events into when audio is not initially present and is initially present in the activities.

The Role of Graphics

When viewing the amount of interaction that took place in the audio channel versus the concurrent use of graphics, the participants elected to use multiple channels (audio and graphics). This supports the Dual Coding Theorem (Paivio, 1979) for effective communication since the participants generally used the channel that was the most appropriate for the information they chose to communicate. Audio was used for cues and descriptions of action, where the graphics were used to illustrate and show relationships.

Graphics were used differently with text. The following exchange from dyad 15 helps to illustrate the differences.

From dyad 15, activity 1, 153 seconds

A- types "Okay, can you read this? Use the big triangles for the top and bottom of the square.
The small pieces"

B- draws small triangle at same time that A is typing.

A- types "make up the sides."

B- erases the small triangle.

A- draws a triangle and erases it, switches from the freehand to line tool.

A- draws and erases a piece of an earlier drawing

A- draws and then undeletes the last erased object.

A- tries to relocate text tool and although the box is clear on her screen when she clicks off of the text, it overlaps previous text

A- types "small triangle at the top right B is simultaneously typing underneath A's text box "

B- types "I've got it so far,

A- types on top of B's text box "square in the middle" while B continues to type

B- types "but where does the trapazoid (sic) and the medium triangle go? "

A- erases what she typed over B

From dyad 15 activity 5 (39 seconds)

B- starts drawing

A- "Ok what you are going to do is …. ahh
You are going to put your square …hold on…. On this side …like here"

B- "At a diagonal?"

A- "Yeah, can you see me drawing it?

B- "Yeah"

A- "And you're going to put the two little triangles sitting on top of the square."

B- "Yeah, I got it"

A- "Yeah

B- "Alrighty"

A- "And then on top of that goes … another triangle, right?"

B- "the middle si.."

A- "The medium size"

B- "Yes"

A- “triangle.”
B-“Right”
A- stops drawing
A- “OK so we’ve you’ve got the solution there.”
B- “yep”

The first major difference is that, with the text mode, a participant can either type or draw. The physical limitations of either using a keyboard or mouse precludes simultaneous action. And, even if it were possible, the text and graphics would both place demands on vision. With audio and graphics, two different senses are engaged and can be attended to. Analysis of time coded events revealed (see Figure 12) the overlap between the descriptive and audio events. This is not to say that it was always the case. It was more common to type what needed to be done and then illustrate what was meant than to first draw and then explain one’s moves. This fits the adage that states, “First, I’m going to tell you what I’m going to do, then I’m going to do it, and finally I’m going to tell you what I did.” This technique was used with audio as well, but not as often.

Time Percentages Across Dyads

Only one dyad (dyad 10) spent more time on the final two activities than on the first two activities. Two dyads (dyads 10 and 19) spent more time on the final two activities than on the middle two activities. It should be noted that dyads 10 and 19 started with audio. The percent of time spent on the last two activities compared to all of the activities was 22% (Table 5). When separated by whether or not audio was available initially, the percent of time spent on the last two activities was 22 and 20 percent respectively (Tables 6 and 7).

Interaction versus Time

Figure 15 illustrates the number of interactions versus time. The tabular representation of these data can also be found in Table H5. Although more interactions might suggest more time spent on task, there are exceptions, notably for dyads 1, 2 and 10. From the chart, dyad 1 had 72 interactions in about 1,600 seconds, dyad 2 had 294 interactions in about 4,700 seconds, and dyad 10 had 979 interactions in about 3,800 seconds. Dyads 1 and 2 started with text, while dyad 10 began with audio. Table 5 shows that between 75 to 80% of the time spent on task is spent on the first four activities. The chart in Figure 15, in addition to Table 5, demonstrate that whether or not audio was first cannot be used as a predictor of either the number of interactions or time spent on tasks.

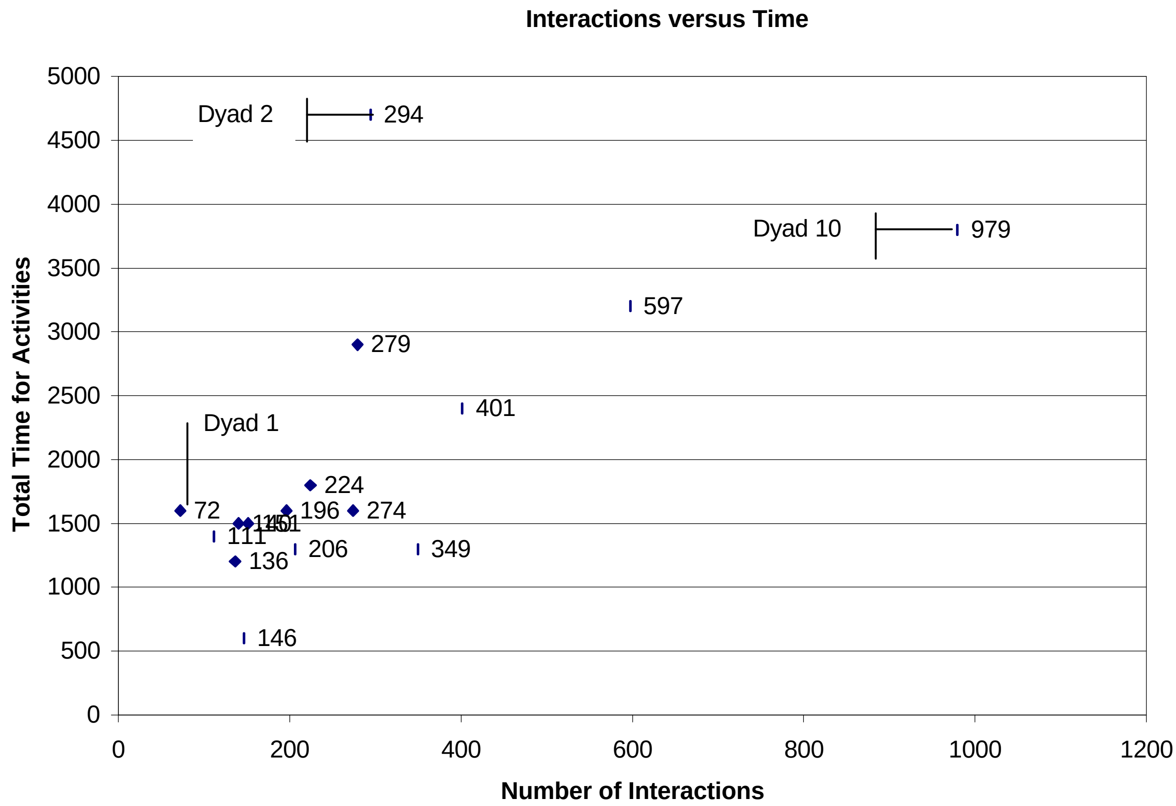


Figure 15. Interactions versus time.

Physical Pieces

Most of the participants, 26 out of 32 in Table 2, used the pieces to solve the puzzle at least part of the time. Neither participant in dyads 2 or 13 made use of the pieces. B1 and B7 did not use the pieces but their partners did use the pieces. Dyads 1, 2, 7, and 13 did not have access to audio initially. Some participants (14 out of 32, Table 2) used the pieces at least part of the time to verify the solutions they were communicating. Fourteen of the participants also used the pieces to verify what they were doing when communicating the solution to their partners. Those who did not use pieces tended to agree with what B1 said, "… it was obvious." A9 started with pieces and then just "visualized". A7 reported in a post question on problems in communicating with her partner that she (A7) didn't use the pieces. Yet, field observations in the room were that she did not use the pieces initially but then manipulated them "a lot". To the same question, A16 responded "She seemed more glued to the screen – and I sensed that she wasn't manipulating the pieces to try to reach the solution on her own." Yet, field observations were that her partner used the pieces a great deal.

Descriptions of Noise, Feedback, and Usage of an SGS

The activity was structured in such a way as to place the participants in a situation that encouraged, if not forced, them to take turns communicating. By alternating which participant had a solution set, the participants had to negotiate how they were going to exchange information. Some dyads chose to have the person with the solution use the graphic space to illustrate the solution, while a few others decided that the solution seeker would illustrate their interpretation of the solution.

Not all of the participants were enamoured with drawing solutions. Written comments such as “felt clumsy” from B5 or from A13 “I generally prefer the verbal stuff- and the whiteboard of course lends itself to the graphic stuff.” B13 went so far as to type on the whiteboard “[F]orget this drawing crap,” but later commented that she liked drawing. Experienced drawing package users commented on the limitations of the tools. One experienced drawing package user went so far as to use only verbal descriptions, until her partner requested a drawing. This was after they both agreed drawing was faster. This experienced user also wrote in the post questions that the tools were “too rudimentary” and that she “felt handicapped.”

B10 wrote in response to the post questions
“It is not easy.
You feel like you do not have control over your communication skills
Not empowering communication.
messing with language capability minimizes what you are capable of in a face-to-face exchange.”

And the other participant in dyad 10, wrote “It was very difficult communicating with one another when you can't see what the other one is doing.” Yet, this dyad had the largest number of interactions, took the second largest length of time (Table 5), and was one of the most dynamic users of the graphic space. Moreover, they laughed throughout the session. But some other participants comments were “[V]ery effective way to communicate” (dyad 13), “[V]ery effective for communicating visual concepts that can't be easily verbalized” (dyad 14). In general , the comments were positive and on the order of “it was fun.”

Simultaneous Action and Limited View

Two major impediments to communicating in an SGS are the nature of simultaneous action in an unstructured space and the limited field of view afforded by the computer monitor resolution. First, not everything “happens” simultaneously. For instance, when drawing a line or a shape, until the mouse button is released, the object is not seen by other participants (Figure 16). A13 commented that “things popped up” and that she didn’t realize that she had to release the mouse button for B13 to see her lines. This problem occurred several times with other dyads. A2 commented that she would have liked B2 to have seen her lines moving before she had to click off. Another related problem occurs with the cursor and is described later.

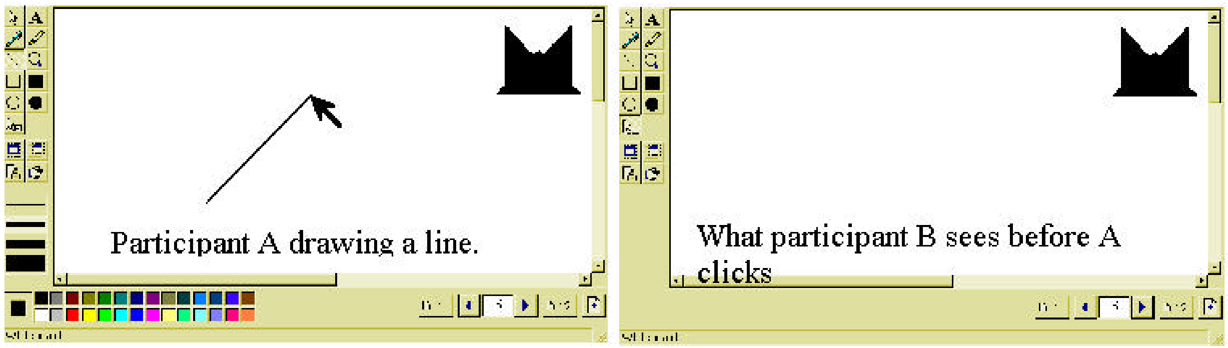


Figure 16. Drawing a line.

The second impediment is that the user has a limited view of the entire whiteboard. The view of the whole whiteboard is constrained and horizontal and vertical scroll bars must be used to view all of it. This is directly related to the screens being set to 640x480 VGA resolution in order to use a scan converter to capture whiteboard activity to videotape. The screen would need to be set to 1024 x 768 to view the entire whiteboard without scroll bars. B2 commented that “[T]he screen size at times could have been bigger.” Participants in several dyads commented on the scrolling display being a problem. For example, B10 commented on “running out of space”. This occurred when starting to draw an object and hitting the left side of the whiteboard. The resulting unseen, unscrolled space was unused space, except when entering text or an accident forced the screen to automatically scroll to the left. When a participant would scroll, automatically or consciously, it would be disconcerting to their partner in the shared space. B5 commented that “[T]yping created a problem when it did not wrap around.” A14 commented, “[T]hat text placement and the need to explain not to type off the end of the screen” caused the most problems with communicating with B14.

In one case, a participant tried to circumvent this problem. A15 switched screens for more space rather than scroll. Most participants were very intent on viewing the screen and the concept of areas of the whiteboard being out of sight was not seen as a benefit, but as an inconvenience. Or at the least, out of space was out of mind.

Whiteboard Organization

The screen layout created its own noise in that it was “messy” (Figure 17). Text and graphics would overlap, comments and responses would be in different areas of the screen, and some but not all of an image or message would be erased leaving a disjointed collage.

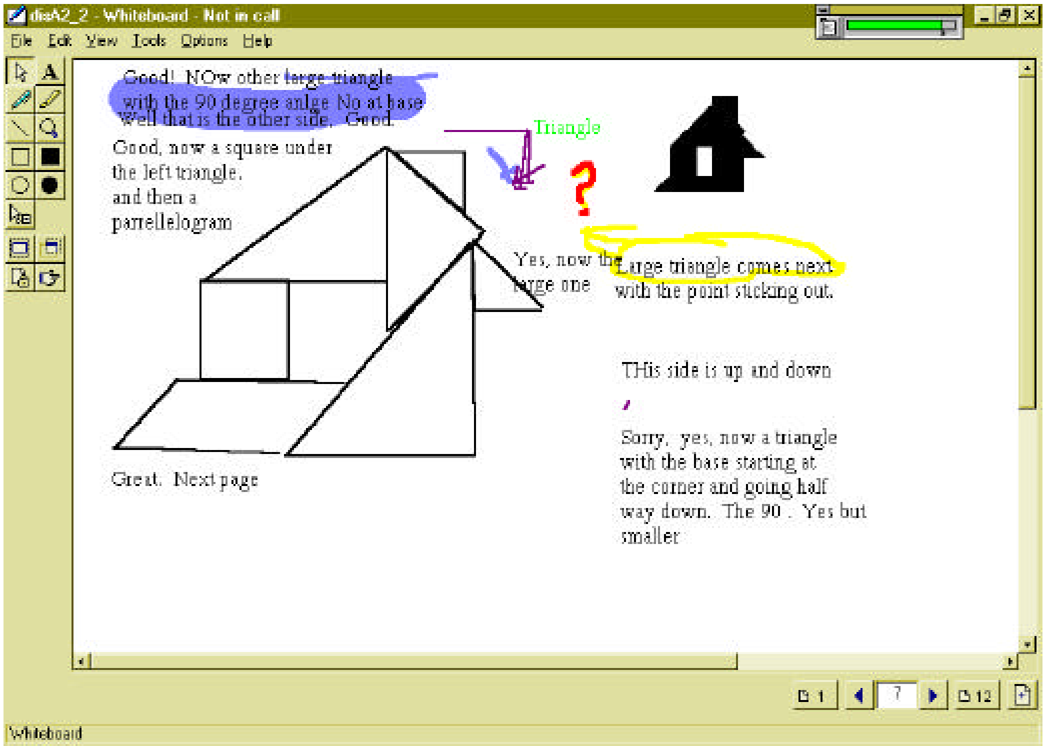


Figure 17. Typical whiteboard screen.

Most dyads, either overtly or by unstated agreement, negotiated private space for text and some drawing, as well as a common drawing area for mutual editing. Several participants remarked that there should be separate private areas or that the text area should be isolated. One member of dyad 15 commented that the screen should be divided into thirds, or top and bottom, and that ground rules should be discussed in advanced. The other dyad 15 member complained about "…our words getting on top of another and the work space becoming totally cluttered." It should be noted that dyad 15 never attempted to negotiate space between them while they were engaged in the SGS.

Another problem that occurred was that a participant would work on one area of the screen while his/her partner would enter relevant information in another area. This creates a temporal/space problem. This relevant information would either "not register" or would be noticed after it lost relevance. B5 answered the post-questionaire on what caused the most problems in communicating with your partner "'[I]nterrupting' his 'space' or not wanting to be sure that I was interrupting with us on the same track." A15 responded in the post-questionnaire that what caused the most problems was "[M]aking mistakes + wanting to start over but not being sure what to erase (it was shared space)."

The dyads were informed several times prior to the activities that they would be engaged in a shared space. It was common for participants to react physically, as with a "start" or an exclamation to themselves, when they realized what a shared space represented. A12, whose self-assessment of computer skills and familiarity was in the upper quartile of the participants (Table H1), stated that she was "scared to death" when the concept of a shared space hit. A16 stated that she thought it was “one way” until the “screen cleared” when her partner erased items on the whiteboard. Participants were often observed to laugh or chuckle to themselves when the computer screen suddenly had an image pop up or erase.

Text Blocks

Unlike chat windows where text appears as a complete word, sentence, or phrase when entered, as text is entered on a whiteboard, it appears as a stream of letters and any revisions are seen real time. For example, a participant may be reading a sentence when suddenly the letters are erased one at a time to correct spelling or change meaning.

A5 left a text block open in order to “keep a personal zone.” It should be noted that an open text block obscures part of the screen (Figure 18) and that

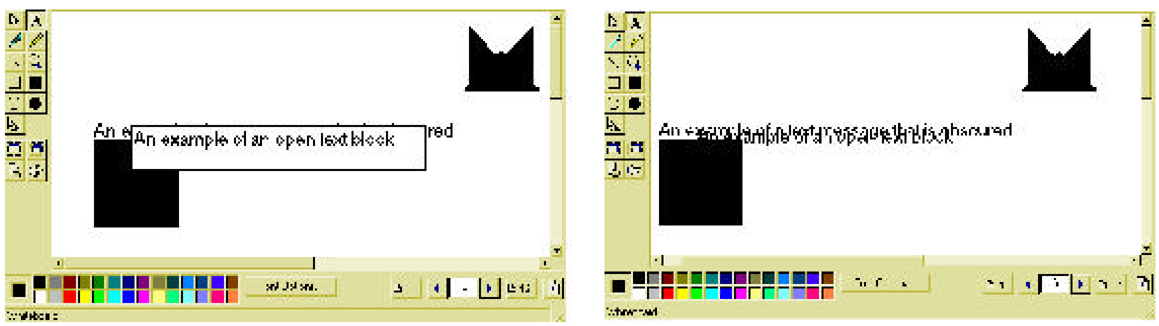
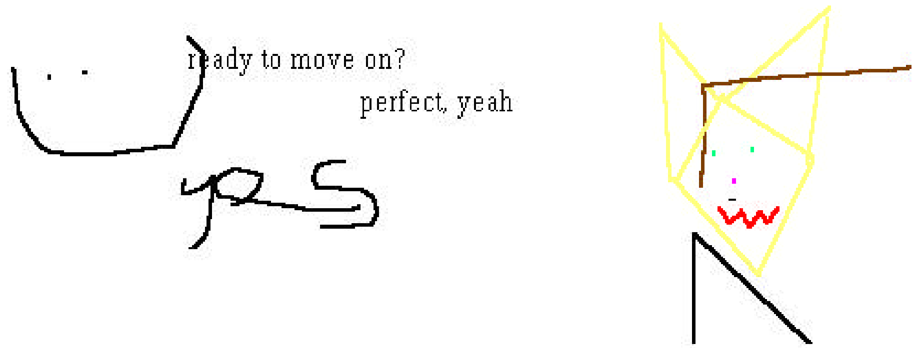


Figure 18. Text block overlap.

anyone can reopen and edit a text block. Also when the text block is closed, the letters can overlap previous text.

Several participants also had problems getting the text tool to “work.” After selecting the text icon, one must click on the screen to begin a text block. Problems arose when the cursor was merely placed on the screen and the participant would begin to type.

Text was occasionally entered “freehand” with a drawing tool to be humorous (Figure 19) or because the tool was at hand and therefore perceived as quicker. For instance, when writing “got it,” “OK,” and “yes” to signify the present task was complete or understood.



Dyad 10 Dyad 13

Figure 19. Freehand humor.

Cursors and Pointers

The cursor produced another common bit of noise. Participants moved their cursors across the whiteboard to point to areas to which they were referring. However, their cursors could not be seen by their partners, leading to confusion. Since only one cursor was visible at a time, it makes one wonder why all groups had at least one participant who fell into this trap. B12 commented that A12 "kept using her mouse pointer to show me things until I told her to use the hand." It was also observed that individuals would acknowledge their error and then repeat it.

On occasion a participant would ask if the partner could see his/her pointer when the hand tool (Figure 20) was visible on the whiteboard, but s/he were using his/her cursor to point out details. Naturally, the partner would agree that s/he could see the "pointer." This led to momentary confusion.

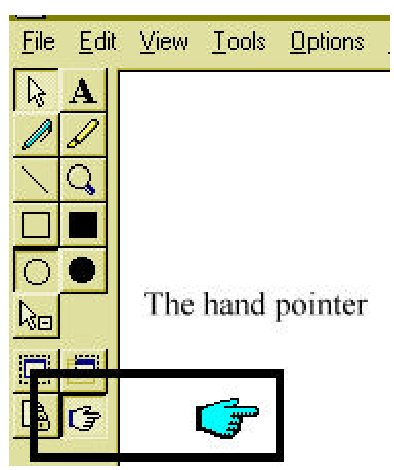


Figure 20. The hand pointer tool.

Several participants, most notably participant A19, would not only continually refer to their own cursors after being advised that the cursors were not visible, but also would refer to their physical tangram pieces as they moved them. This would appear to demonstrate that the whiteboard cursor was symptomatic of another issue in communicating.

Drawing Tools

The whiteboard was not designed for creating graphics, but as a means of sharing, illustrating, and communicating. Copying and pasting would be more appropriate for less constrained, more realistic working situations. As was noted earlier, the "rudimentary level" of the tools created problems. First, the more experienced users decried the lack of a rotate option so that they could create a palette of reusable shapes that could be adapted to each problem. One average (Table H1) user, B2, remarked that "experience worked against me" when looking for a "grouping" tool. Several other participants also searched for a "grouping" tool. A "grouping" tool selects multiple screen objects and creates a new object made up of the combination of original objects. Without a grouping tool it would be as if to move a toaster across a room you had to move each individual part of a toaster, or hold all the parts together as they are moved, instead of the whole item. A tool for creating triangles was also mentioned several times.

The erase and selection tools are object oriented. Instead of erasing or selecting parts of an image, one selects individual objects that created the image. Part of a line could not be erased or selected, it was all or nothing. Clicking on any part of an object selected the whole object. This created problems for less experienced users as well.

Participants tended to settle on a tool and "made do" with it. The most common tools were the freehand tool and the line tool. For example, dyad 9 had in its second screen (Figure 21) two drawings, one to illustrate tangram placement, the other to show that it was understood.

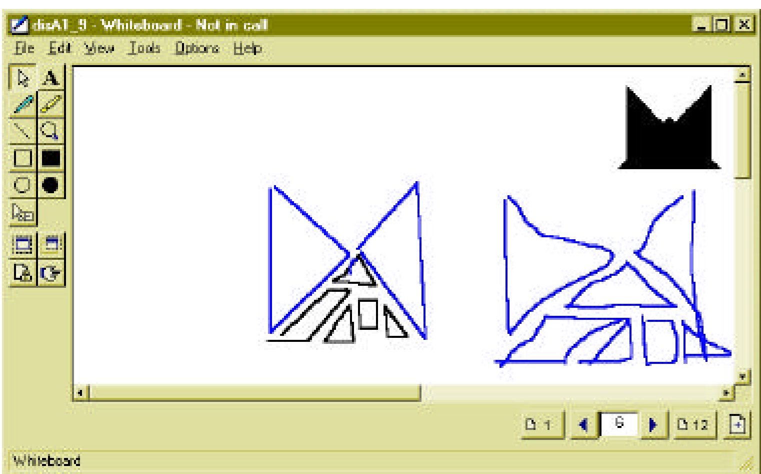


Figure 21. Line versus freehand tool.

Participants in the same dyad would sometimes stay with different tools. For example, one participant would use the freehand tool and his/her partner would use the line tool. The freehand tool often led to illegible drawings as in Figure 22 from dyad 6. B6 used the freehand tool and never tried a different tool even though his partner was making better images. He never asked how and she never volunteered, even though she was very encouraging and never negative toward his obvious problems with communicating. She would apologize as she modified his drawings to increase legibility and would denigrate her own drawings with comments like “I can’t draw” or this isn’t very good.

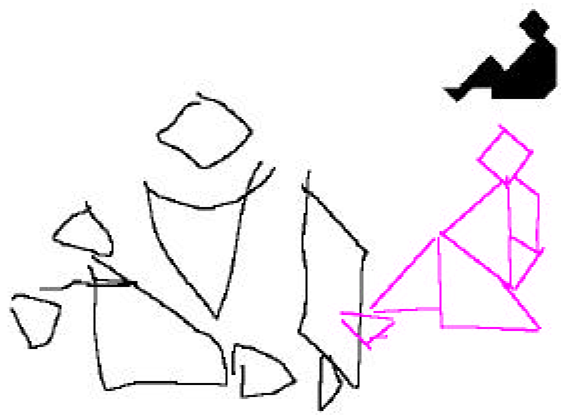


Figure 22. Freehand drawing problem.

Assorted Other Problems

Some participants had problems that were not directly related to the SGS. B6 had problems controlling the use of, and using the buttons on, the mouse. He initially said that he used a mouse , but after the session commented that his computer at home (a PC) was different. He also had the lowest score on related computer familiarity in Table H1. Several other participants accidentally hit the right mouse button and entered menus that temporarily confused them. A19 had the most problems with the program minimizing and calling up unexpected functions. It is interesting to note her high self rating in Table H1.

Several software computer crashes eliminated dyads 3, 4, and 11. The software corrupted the data and/or crashed repeatedly. Several times computer error messages occurred in other dyads, but these did not cause a problem for the participants. It appears that most computer users take software glitches in stride.

Non-computer related concerns were largely relegated to lack of initial focus and direction. The questions after viewing the videotaped introduction to Netmeeting’s™ whiteboard were minimal. A14 remarked on how the tape covered all the tools in a clear relevant manner by example, instead of the usual stepping through each item. He went so far as to recommend coworkers for the study so that they could see an alternative, effective approach to training. A participant in dyad 13 remarked that she “enjoyed learning tools in this format.” But in spite of similar responses from other participants, a number of the participants had some difficulties with choosing and enabling tools. As a participant in dyad 8 responded to her partner “ … I guess I wasn’t paying enough attention to the tape.”

Taking into account that:

- the participants in each dyad were instructed that they would alternate having the solution to a series of tangram puzzles,

- they were informed that it was not time dependent and that there were no constraints on time or the approach they wished to take,
- they would have physical pieces to solve the tangram at their disposal,
- when they possessed a solution they were to communicate it to their partner so that their partner could solve the puzzle,
- they could use audio for only part of the session and would be instructed when,
- the participants were questioned as to their understanding of the activity and often repeated to the observer what was to be done,
- all acknowledged the solution sheet and physical pieces,

upon starting the activity, the majority of participants proceeded to forget everything. This occurred even though some of the instructions were repeated on the screen (Appendix G). Several participants admitted to not following directions well or at all. A2 stated that she felt that her partner " … doesn't read directions well" and that "… someone needed to take charge." Her partner admitted she was right.

Participants were initially placed in a position where they had to negotiate between themselves on what was expected and how they would achieve that end. Each group approached the solution sharing, and verification of whether it was communicated, in a unique manner. One interesting trait was that some dyads felt they had to "color in" the pieces because that was how the solution looked.

The last non-software problem was the pressure on time. The participants were informed that there was no time constraint, yet as an excerpt from comments by dyad 16 reveals

"Fun, but why do I feel like I'm in a hurry? He said no time rules...."

"Because, this is a timed event even if it wasn't expressed that way."

Several other participants expressed this sentiment.

Feedback and Interaction in the SGS

Superficially much of the feedback between participants was of the nature of "got it," etc. But when one considers how strategies for communication changed or evolved, another view of feedback emerges. For instance A17 drew and labeled the pieces without describing how the pieces would solve the puzzle. Previous sections had evolved from describing through text and then drawing, to drawing the whole solution and labeling afterwards, to finally drawing a piece and labeling it immediately afterwards. When audio was introduced, B17 remarked "… but at least you can point to objects and say what they are rather than write the label." This evolution of technique is indicative of feedback. The use of labeling evolved and was continued to be used because it was a successful strategy and was accepted by both participants.

Feedback through continued use or adoption of communication strategies was not always present. By examining Table H6 one can see that some participants used text to label pieces, but his/her partners did not. Or a participant used the pointer tool often, but their partner did not. Continued use of a strategy by participant X might mean that there was feedback from their partner Y, not that it worked for X. If participant Y either does not use, or only briefly tries a strategy that X uses, that can indicate that X gave feedback that some other strategy was more appropriate for X.

The nature of the feedback in the SGS was idiosyncratic because of the various approaches adopted by the dyads. The SGS promoted a rich environment for options in communicating the solutions to the tangram problems.

Motion

The main use of motion by the dyads was with the hand pointer tool (Figure 20) circling or tracing an outline of the tangram shapes, without actually drawing the shapes. The second most often use of motion was using the hand tool to point to a puzzle piece and then to point to the piece's relative location in the entire image, or conversely from a location in the image to a puzzle piece.

In one case, A1 moved the original screen image to be solved on top of an arrangement of pieces representing the solution and then moved it off in order to illustrate the solution (Figure 23). The main reference was on the placement of the "hole.". This was the only time this technique was used.

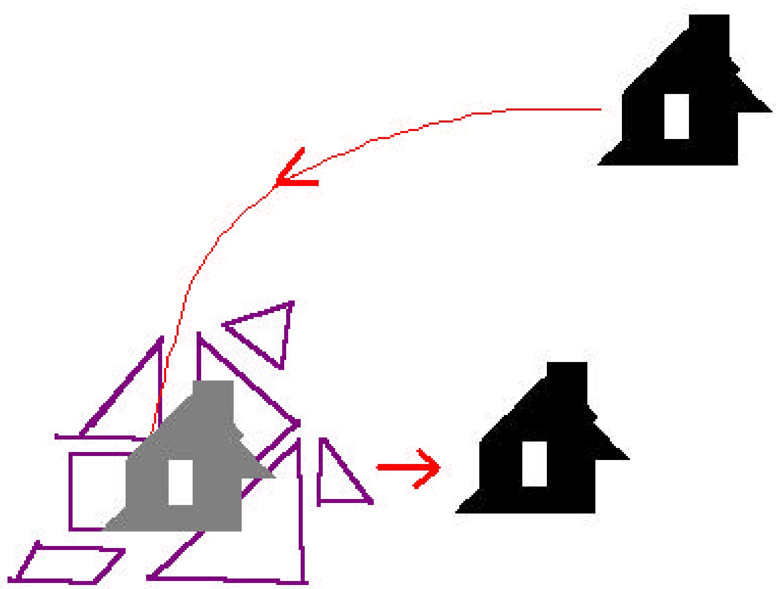
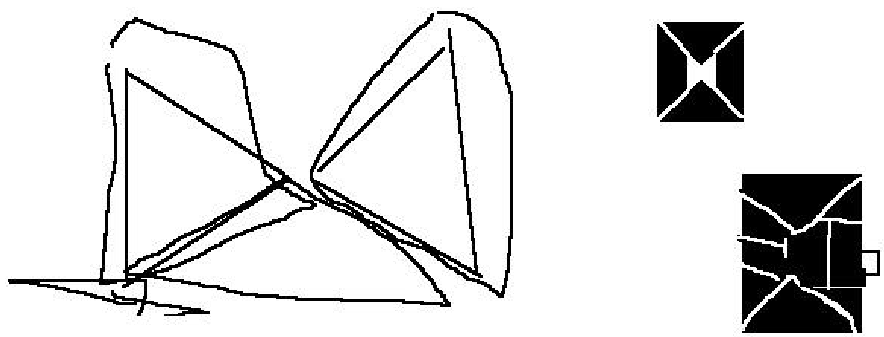


Figure 23. Moving an image to reinforce relationships.

Static Images

As mentioned earlier, since text and drawing could not coincide, only one tool could be used at a time. The use of graphics was either before or after the typed descriptions of the solutions. Several dyads tried this approach with audio, but the majority used audio concurrently with the graphics, drawing as they spoke. Depending on the dyad’s approach to communicating the solution when audio was used concurrently, some participants drew as they were describing what their partners needed to do in order to solve the puzzle. In some other dyads, a participant drew what s/he perceived to be the solution based on instructions from their partner. Although the approaches were different, there is common ground in that the drawings were related to instructions and were tied to descriptions of the solutions. The drawings did not appear in a vacuum. A case of drawing with no prior communication did occur with dyad 2, but it was the during the first problem and the dyad did not repeat that approach again. Whenever a dyad did draw with no description, it would follow a procedure that was already used, as in the example of dyad 17 at the beginning of this section.

Figure 24 illustrates two ways in which lines were used to indicate placement of pieces. In dyad 6 the use of straight lines was a means of inquiring whether the assumed pieces (triangles) were correct. It could be considered feedback when the white lines used in dyad 8 are for illustration of where the pieces go. The feedback would be acceptance or rejection of the technique.



From Dyad 6 From Dyad 8

Figure 24. Drawing on top of an image to clarify or describe.

Summary

This section addresses the research questions with respect to what was revealed in the study and how what was uncovered relates to the literature. Each research question is presented in turn.

The Nature of the Communication Events in the SGS

The SGS was a method (Clark, 1991) to express solutions in dynamic and static ways. The SGS supported cognitive processes by serving as a scratchpad for visual information while providing a channel for interaction. The SGS provided an avenue for shaping information beyond, and extending the openness found in, text-based CMC (Davie & Wells, 1991). The SGS did lack non-verbal cues (Ishii et al., 1993; Kiesler et al., 1984), but the existing channels provided cues for each other (Hsia, 1968). The cues between text and graphics were often different from the cues between audio and graphics due to audio and graphics often occurring simultaneously as opposed to text and graphics which occurred sequentially.

In order to function within the unstructured environment of the SGS, the dyads attempted to evolve their own etiquette for interaction. This etiquette was predicated on what was necessary to complete the task and was in effect a pattern of interaction. The task driven activities (communicate and verify solutions) encouraged the participants to focus on what worked to communicate solutions, rather than freely exchanging information. Even when participants would drift off task, as in B10’s humorous freehand drawing (see Figure 19), they would resume a pattern of interaction that “would get the job done.”

The study supported the idea that an SGS acts as an affordance (Gibson, 1977). An affordance is something that helps to make activities possible but not inevitable (CTGV, 1993). Although a range of capabilities for communication existed, they were not always exploited by some or all dyads.

The communication environment included physical pieces that could be used to solve the puzzles The tie to an actual physical activity was exploited by most participants. However, the availability of these pieces did not guarantee their use. Two of the dyads did not refer to the physical pieces at all. The physical pieces also supported the concept of an affordance enhancing the means to interact within an environment but not guaranteeing that type of interaction.

The graphic capabilities inherent in the SGS were an affordance to present and manipulate visual information. Although all dyads used graphics in some manner, the graphics were not always used for all activities. The total number of intervals in which text and audio were present, as well as the total number of interactions for text and audio, exceeded the number of intervals and interactions for graphics for most dyads. Those where graphics were used in more 10-second intervals than text and audio were ones in which audio was introduced later. Since audio tended to provide more exchanges between participants, the longer that audio was used, the greater the ratio of audio to graphics that could be expected. When audio was introduced later, fewer interactions could be expected and resulted in a lower ratio to graphics. The patterns of interaction for using text with graphics and for using audio with graphics are different. Text occurred before or after graphics while audio could, but not always did, occur concurrently with graphics. The redundancy of text and graphics or audio and graphics supports the Dual Coding Theorem (Paivio, 1979) in that the dyads freely chose multiple channels to communicate because it worked for them.

The comparison of the audio first and audio introduced later dyads may not be valid, in that once graphics were entered into the whiteboard, they were afforded persistence in the field of view. The graphics, whether or not they were directly referred to, were available for reference. Even though a participant could be typing, it was no assurance that his/her partner was paying attention to the typed words. The partner could be analyzing images in the whiteboard or for that matter the physical pieces before them. The graphics continued to communicate although they were not being manipulated or created. Graphics were referred to by text and audio as well as when physical pieces were being used.

The role of graphics was the major focus of this study. Graphics were assumed to be an independent channel for communications and, as such, possessed the attributes of feedback and noise in their use. By using a single framing activity with and without audio capabilities, it was conjectured that there would be certain characteristics of communicating with graphics that would be common to communicating with audio and text. As all good intentions must give way to reality, so did this idea. It appeared that audio was supported by images rather than the other way around.

Hsia (1968) recommends a large degree of cross-channel redundancy and states that one channel provides cues for another. In a way this could be a form of self-correcting feedback in that discontinuities in the information (noise) contained in several channels would cause the participant to question whether they understood what was being communicated. There was a good deal of repetition between what was typed and how the graphics were used, as well as between what was said and how the graphics were used. While dyads did not behave consistently, they each tended to evolve in their use of the SGS. Patterns did emerge, participants did employ similar techniques using graphics.

Audio was the dominant mode of communication. When audio was present, text was rarely entered into the SGS and then only for labeling parts of images. When dyads had audio capabilities for the first four activities, they tended to spend a smaller percentage of time on the second two activities than those that used text for the first four activities. When audio was removed they spent a greater percentage of time on the last activities than the groups that switched to audio for the last two activities. This would raise a question related to Salomon’s views of mental effort (1981, 1983). Although the redundancy of graphic and verbal information falls in with Paivio’s views in the Dual Coding Theorem (1979), it may fall short of text in learning to use this system of communication. Another view would be that text and audio are conjoined with graphics in a different manner and that comparisons cannot be made. This is an area for further research.

The Nature of the Noise When Communicating in an SGS

The noise in the SGS was primarily caused by the open nature of the communications in the SGS. The interface and expectations were also contributing influences.

The participants had a limited view of the entire whiteboard and had to use horizontal and vertical scroll bars to navigate the graphic space. This, combined with the edges of the space, constrained the graphic interactions. Until a scrollable or fixed boundary was reached, there was no noise attributable to it. It was when the boundary caused a disruption in communication that the noise existed.

The shared aspects caused their own unique noise. One type of noise arose when the participants negotiated private space and had to deal with another form of boundary instead of with the information directly. The attempt to structure the unorganized aspects of unstructured space became entangled with the information the participants were attempting to share.

The simultaneous nature of the graphic space caused noise in that while a participant was engaged in one area of the whiteboard, his/her partner was entering information in another area of the whiteboard. Synchronicity became an elusive illusion. It appeared that they were communicating and attentive to each other when, in fact, they were engaged elsewhere in the SGS.

Negative effects through overloading by multiple channels were not observed (Hartman 1961b; Hsia, 1968). This was probably due to the participants deciding which channels they would use. But each channel contributed its own form of noise. Several participants remarked on either screen size, audio noise (static, etc.), and /or problems with entering text. These forms of noise could be modeled according to Shannon and Weaver's model (Heinich, Molenda, & Russell, 1993; Littlejohn, 1978; Neulip, 1996; Shannon, & Weaver, 1971; Wagner, 1994) in Figure 4.

The SGS interface did interfere (Norman, 1990) in that the open, unrestrained communicative environment was in fact a limited virtual environment. The space scrolled but had boundaries and when these boundaries were reached, images had to be moved. The participants who had problems with this were brought to a halt as they investigated "work arounds" or adjusted their descriptions and changed their tack.

The object oriented nature of the interface also caused problems when selecting for moving, copying, or deleting. Instead of capturing part of the image, components that made up the image were selected for moving, copying, or deleting.

Another interface issue was the use of text blocks. Because the blocks were not transparent, they interfered by competing (Neulip, 1996) with the participant's view of other information.

When audio was unavailable, the communications were limited to either using a keyboard or a mouse so that only one channel was available at a time. And, even if it were possible to use a keyboard and mouse concurrently, the text and graphics would both place demands on vision. Even with a graphic image available, only one channel (text or graphic) could be attended to. Switching back and forth between channels meant holding information in short term memory while taking in new information. The decoding process took time and more cognitive resources as opposed to the simultaneous delivery of audio with graphics. With audio and graphics, two different senses are engaged and can be attended to.

Problems caused by references to cursors were largely due to expectations of the SGS showing simultaneous entry of information. This gives the impression that all information is shared, when in fact some is not. The individual's cursor was an example of this false impression as were open text blocks covering parts of the screen. This problem with a false sense of a shared space also occurred when drawing lines or objects which could not be seen until the mouse button was released or when erasing and undeleting. This created the sense of images popping-up.

The Nature of the Feedback When Communicating in a SGS

Attempts to provide feedback through the non-verbal cues that were missing in the SGS (Ishii et al., 1993; Kiesler et al., 1984) consisted of inserting freehand drawings which served the purpose of emoticons. The other channels provided additional sources of compensation through supportive verbal and textual statements as well as inflections in the audio channels and humor in text.

Much of the feedback between participants consisted of information in the audio and text based channels referring to graphic images or actions in the whiteboard. Some feedback occurred through moving images or pointers as verbal descriptions and directions were given. This is consistent with Hsia's (1968) view of one channel providing cues for another.

Although some feedback reinforced (Mory, 1996) techniques for communications in the whiteboard, most of the feedback was task related. The task related feedback was informative, immediate (Travers, 1977) and directed to constructing correct solutions to the problems and, therefore, was cognitivist (Mory, 1996). The audio was usually concurrent with the use of graphic tools in the SGS where the text was used before or after the use of graphic tools. For instance, using a draw tool to circle, or the pointer tool to trace an outline of the tangram shapes and solutions, was rarely used without concurrent audio. Responses and comments from the participants favored the audio as the more effective addition to the SGS which coincides with Travers' (1977) assessment as to concurrent feedback being more effective than terminal feedback.

Feedback through continued use or adoption of communication strategies was not always present. Feedback through the use of tools was present. If a participant had difficulty in using a tool, there was immediate feedback on the computer screen. The participant would then decide to continue to refine the use of the tool or discard it in favor of another tool or tactic. This feedback was for regulation and control of the tools and could be modeled by cybernetics (Littlejohn, 1978).

Each participant brought his/her own areas of knowledge and skills into the activities. When viewing those skills and knowledge as the participant's field of experiences, the Shannon-Schramm Communication Model (Henrich et al., 1993; Wagner, 1994) in Figure 6 becomes an appropriate model for the participants' interactions. The participants used the fields of experience to create viable communication tactics between themselves. The positive (regenerative) and negative (degenerative) feedback that they received from each other guided the creation of these tactics. Because they alternated solution sets, each participant was able to develop skills within the environment and try approaches that stemmed from their individual fields of experience. Each in turn was a master and an apprentice, not in the sense of true mastery of the tools, but in the sense that they were the source of some "knowledge" or solution that was passed on. They guided or "scaffolded" each other in turn (Brown & Palincsar, 1989; Rogoff & Gardner, 1984). This movement in, through, and outside of their field of experience is illustrative of movement within the ZPD.

The feedback mechanisms in the SGS were not limited to a single channel but were based on how the participants negotiated their approach to the tasks. This negotiation resulted in the use of a limited number of tools and techniques for each dyad. When descriptive techniques were used, one of two techniques emerged; either a participant would draw a representation of their partner's drawing in another area of the whiteboard or they would directly modify or draw over their partner's drawing. When active techniques were employed, a participant would move a pointer to show where a piece should go, erase what appeared to be inaccurate, or outline a shape without explicitly entering it into the SGS. Static highlighting was used only to identify parts or text through drawing a circle, using a pointer (or drawing a mark or arrow), or actually highlighting with a different color. Some combination of these techniques was observed within all of the dyads, but not all of the dyads used the same techniques.

Chapter 4
Discussion

The purpose of this study was to investigate feedback and noise in an SGS. However, as the study progressed, other questions regarding the interactions in the SGS arose. Because of the number of participants, generalizations are not warranted and the statements in this chapter should be viewed with this in mind. The summary in Chapter 3 addressed the research questions in this study, this chapter begins with general observations based on those findings. The second section addresses problems that arose and different perspectives that could have been taken in acquiring and analyzing the data from this study. The last section of this chapter addresses issues that arose during the study and further avenues of inquiry.

Observations on the Interactions within an SGS

Sometimes the ability to communicate at a distance and to collaborate in the construction of knowledge requires more than text, audio, and/or video. That realization was the initial driving force to investigate an SGS. The researcher's experience in education identified the SGS as bringing a degree of interaction with graphics that supports math, science, and engineering disciplines for distance education. Whether or not an SGS was appropriate for education became the impetus for a study that led to this dissertation. As plans for this study developed, the difficulties in isolating the important aspects of communications with graphics drove this study to a postpositivist stance (Guba & Lincoln, 1994). Quantifying aspects of communications in an unstructured space became a struggle between trivializing the interactions and overgeneralizing those same interactions. By framing the graphic components of an SGS as a channel for communications, the touchstones of feedback and noise became a foundation for examining the interactions that occurred even though feedback and noise barely reflect what was uncovered by the study.

The manner in which graphics were used was dependent on whether they were accompanied by an audio channel. Graphics tended to be used as part of the "conversation" with audio. Audio afforded (Gibson, 1977) the participants the opportunity to use multiple channels to communicate simultaneously, and the participants took advantage of it. Audio encouraged a high number of communication exchanges when compared to text and these exchanges were usually concurrent with graphics. This resulted in immediate feedback between partners. Occasionally when using text, a participant would continue to type unaware that his/her partner was entering relevant information for feedback into the whiteboard. Text could not be used concurrently with graphics and the participants could not read and view images at the same time. This defined the manner in which graphics were used. The contexts for the use of graphics with audio and with text were therefore different, even though descriptive, action, and highlight events were the same categories for graphics with audio and with text.

The unstructured nature of an SGS, while creating some problems, contributed to a variety of approaches to communicating by the participant. This idiosyncratic use of an SGS is indicative of the freedom to communicate afforded by the SGS. The visible space of the whiteboard was the communication space. Even though there was available space to scroll into, the participants entered that space only by chance or when a stream of non-wrapping text was entered into the whiteboard.

This unstructured space, that allowed simultaneous entering of information anywhere within its boundaries, paradoxically created a need for a personal space or region. This need expressed itself as a pragmatic etiquette for communication that evolved between participants, but was dissimilar across dyads. The SGS encourages new ways to interact and unique patterns of interactions between users. As the number of users increases, a danger lies in imposing structure in order to coordinate activity. This would stifle creative use and create preconceptions in users by implying a right way to do things in an SGS. What the literature suggests, and the study revealed, are that spaces exist for personally unique, collaborative engagements for learning.

Problems and Different Perspectives

Technical difficulties in keeping the hardware and software running are common to all studies involving computer technology. This study was no exception, but because of the type of data that was to be acquired, several unique issues arose. A single scan converter was used to capture the information on one computer screen since it was assumed that the data were the same on both screens. The problem that arose when the text box of a participant covered some or all of the text their partner was simultaneously entering into the whiteboard is a counter case. In dyads 6 and 19, participants were accidentally opening menus and minimizing the whiteboard, this activity was not seen on both participants' screens. The cursor movements that did not result in information being entered but were exploratory (checking menus, selecting but not using tools, etc.) were not available for both participants. Although the researcher did not find this to cause a problem in the analysis for this study, it might cause a problem if the data were revisited in more detail as to what occurred in particular situations or for analysis of interface issues.

Instead of using the computers for communicating with audio, an external audio communications channel was constructed. This permitted recording both participants on a single tape in sync with the screen activity. It also permitted recording participants talking to themselves when they were not connected to each other's speaker or headset. While simplifying the data acquisition, the external audio channel caused problems with identifying which participant was A or B and sometimes necessitated repeating an analysis.

While the training tape was a quick way to introduce the participants to the functions of the various tools, the participants were not fully trained in them. This may have had an effect on how they decided to communicate. The trade off was that training in using the tools might have resulted in creating a script on a single "correct" way to act as opposed to letting the participants evolve a system of usage. Using a whiteboard to solve problems was not the object of the study. Communicating in the SGS was at the heart of the study.

Field observations of actions not recorded in the audio channel or in the whiteboard were adequate for this study. Whether and when the physical pieces were used were the main data sought. The computer monitor and audio channel were all the participants "saw" in communicating. Anything outside of the monitor and audio channel, while contributing to the individual participant's context, did not exist for his/her partner and was extraneous to the activity in the SGS and this study. Videotaping the participants was tried in the pilot study (Appendix I) and was not used for this reason. A study on individual reactions to and interactions with the SGS would require extensive field observations and/or videotaping.

Data from this study could be revisited for the purpose of analyzing the dynamics of the audio exchanges and the text exchanges in order to isolate the differences in communication between text and audio that occur in an SGS. These exchanges could be compared to "chat" sessions and traditional audiographic courses. Again, this was not the purpose of this study, but would be a different point of view in analyzing the activities.

New Directions

The interactions within an SGS have led the researcher to other areas for further investigation. Far more questions were raised than were addressed. The questions can be divided into what are the effects on communication and interactions due to the individual and due to the attributes of the SGS. Some of the questions that arose from reviewing the videotaped whiteboard interactions are:

- What types of interactions occur when text and audio are not options, as with dyads of young participants who do not type or can enter freehand text?
- Why was a greater percentage of time spent on the last 2 activities when there was no access to audio than when there was access to audio?
- Does the ease of using audio create a more dynamic system of interaction at the expense of the reflection that may occur in entering text?
- Are text and audio conjoined differently with graphics for communication in an SGS?
- What are the interpersonal dynamics that develop between participants when engaged in an SGS?
- Is there an appropriate universal etiquette for an SGS?
- Are there cultural and/or gender differences in interacting in an SGS?
- What are the boundaries for personal space that need to be maintained within an SGS?
- How is "leadership" or the power dynamics in an SGS different from other forms of communication?
- What happens when a communicant can cut and paste from other sources? Does the SGS then become more open to new uses, or constrained to a conduit for presentation of existing information?
- How do all the above change when more than 2 people interact in an SGS?
- Are there better interfaces and input devices (i.e. digitizing pens) for communicating in an SGS? And do they alter or enhance the use of an SGS?
- What happens when the 2 dimensional SGS is expanded into 3 dimensions?

Sharing computer mediated space is not the same as sharing a physical blackboard. The degree of interaction, the immediacy of event, and the loss of ownership of data are issues that are evident in use and in observation of that use. These issues are not easily communicated but they are easily experienced. Whether this form of CMC is liberating and empowering to learners will remain to be seen. The need to continue to investigate and to employ an SGS is evident to this researcher.

Appendix A

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants of Investigative Projects

The Purpose of this Research Project

This is a study to identify the significant aspects of different forms of computer mediated conferencing. The results will be used to support the use of and additional research in the graphical components of computer conferencing.

Procedures

You will be asked to view a videotape on using computer conferencing software. You will then be asked to use the software to communicate with another person through a computer network. This communication can involve text, graphics, and/or speech. The entire procedure should take no more than 90 minutes.

The results of your activities on the computer screen, your voice and any additional comments will be recorded. The recordings will be erased at the completion of the project.

Risks and Benefits of this Project

There are no known risks involved with participation in this study.

No promise or guarantee of benefits are made to encourage participation in this study. Results of this study will be documented and shared with the educational community through papers, workshops, and conferences.

Extent of Anonymity and Confidentiality

The identity of the subjects will not be recorded, a code will be used to link the information to the data. All recordings and information gathered as part of this study will remain in the possession of the investigator and shall remain secure from unauthorized access.

Freedom to Withdraw

Subjects are free to withdraw from this study at any time without penalty. There may be circumstances under which the investigator may determine that a subject should not continue as a subject. In either case, withdrawal will not result in them being penalized by reduction in points or grade in a course (if course credit is involved). Because no compensation is involved, no penalty or forfeiture will be incurred as a result of withdrawal. Subjects are free not to answer any questions or respond to experimental situations that they choose without penalty.

Approval of Research

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University.

Subject's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I understand that if I participate, I may withdraw at any time without penalty. I agree to abide by the rules of this project.

Should I have any questions about this research or its conduct, I may contact:

Carmel Vaccare	Investigator	231-5587	cvaccare@vt.edu
Dr. Glen Holmes	Faculty Advisor	231-5587	gholmes@vt.edu
Jan Nespor	Departmental Reviewer	231-8327	
Tom Hurd	Instructional Research Board	231-5281	

I hereby acknowledge the above and give my voluntary consent for participation in this project.

Participant ________________________________ **Date** ____________________

Appendix B

Code_______

Instructions
Using the following scale for the questions below.

1..............2..............3..............4..............5..............6..............7

completely unfamiliar	somewhat familiar	completely familiar

How would you rate your overall familiarity with computers? ①②③④⑤⑥⑦

Please rate your familiarity with using computers for each of the purposes below.

1. Word Processing	①②③④⑤⑥⑦
2. Desktop Publishing (e.g. Pagemaker)	①②③④⑤⑥⑦
3. Drawing	①②③④⑤⑥⑦
4. Graphics (e.g. Photoshop)	①②③④⑤⑥⑦
5. E-mail	①②③④⑤⑥⑦
6. Interactive Discussions (e.g., MUDs, MOOs, chats)	①②③④⑤⑥⑦
7. Computer Conferencing	①②③④⑤⑥⑦

Appendix C

Post-Session Questions

Code________

What are your general thoughts on using a whiteboard for communication?

How did the layout of the whiteboard affect your ability to communicate?

What did your partner do that was effective in communicating with the whiteboard?

What caused the most problems in communicating with your partner?

What interfered with understanding your partner?

Appendix D

Post-Session Questions and Responses

Note: All misspellings, etc. are faithful to the original answer sheets.
For AX-Y or BX-Y: A,B are the participants; X is the dyad;
Y =1 for audio was initially available
Y=2 for audio was introduced later.

Prompt: What are your general thoughts on using a whiteboard for communication?

A1-2
I liked it, I really didn't like audio, and I preferred to type & draw. I was really worried about the shapes because I am very field dependent. I was surprised I could put them together at all.
B1-2
At first it was confusing but I caught on after awhile and really enjoyed it. It was fun.
A2-2
It's great if you can talk and point.
B2-2
I believe it would be great for familiar communication or in a structured format where the two understood what they were to do.
A5-2
Whiteboard seems a natural tool for this form of communication. Audio added dramatically to the experience. Typing made the whole process slow down without advantage (mostly). Typing also had the terseness common in email.
B5-2
Really liked being able to draw for this particular task. Combing that with text was great. Lots of times I reach for a pencil and paper when I'm talking - this was very nice. Allows nice "shorthand" for people thinking alike.
A6-1
I prefer talking, but the whiteboard can be used, although it's a lot harder. I forgot that you could use the text until the end when we couldn't talk.
B6-1
I was confused at first. But I was able to figure out what was going on.
A7-2
Fun.
Really realize how different views people have.
B7- 2
An interesting forum. I think that it can be quite useful.
A8-1
I thought it was strange at first.
But got used to it.
B8-1
I really liked it. I'm intrigued now.

A9-1

The whiteboard is a poor replacement for hand gestures, however it is a much more efficient medium than voice communication.

B9-1

Nice, better integrated text chat would be a lot better.

A10-1

It was very difficult communicating with one another when you can't see what the other one is doing.

B10-1

It is not easy. You feel like you do not have control over your communication skills

Not empowering communication.

messing with language capability

minimizes what you are capable of in a face-to-face exchange.

A12-1

It was fun once we figured it out

B12-1

The hard part was working out the communication kink - I think it took us longer to do stuff when using the verbal communications. This would be great for classes studying the same stuff at the same time in different schools.

A13-2

Well I guess in the aspect in which we used it (problem solving) it was okay.

It depends on what you wanted to communicate. I generally prefer the verbal stuff- and the white board of course lends itself to graphic stuff.

I didn't like looking at the ugly stuff (miserable attempts at geometric shapes)

B13-2

A lot like using email. Very effective way to communicate.

Took a minute to get used to at first.

A14-2

Very effective for communicating visual concepts that can't be easily verbalized. Slower for things easily verbalized as it is limited by typing speed.

B14-2

If you have objects to be manipulated I could see where it would have advatages over just a text confining system

A15-2

For collaborative projects dealing with the need for illustrations, graphics, etc. It’s great. I keep wondering if one could adapt it for writing/composition conferences with English teacher + student analyzing student writing projects.

B15-2

Interesting. Has potential but would need some preping/instructing for the users so we don’t flounder. Guidelines (unintelligible) use perhaps

A16-1

Fun- a little limited since rotation, etc. wasn’t possible for this exercise.

B16-1

Fine, but tools too rudimentary – felt handicapped

Having text helps for discussion - afterwards.

A17-2

It is challenging, but with practice can become easier.

Knowing the other person or working with the other person may help the communication process. Being able to draw straight lines or practicing using the various tools would also help.

B17-2

It's not as natural as face-to-face communication at a real whiteboard, but with some time to learn how to use this tool, it would become very useful.

A18-1

I think this has some really neat possibilities – I'd love to be able to play and work on some instructional ideas –

This is great

B18-1

Fun, audio was nice, but at least typing makes a suitable backup.

The whiteboard makes verbal descriptions enhanced by drawings, if you have just a tiny-bit of skill though.

A19-1

I initially thought that communication would be difficult, but I had a great partner, and we were able to communicate with little or no problems with the tools that were provided.

B19-1

I'm impressed. Seen it demo'd but haven't used it until now!

It's a definite plus for communication – especially to consider pulling documents or images into it for analysis.

It's fun but I can see how it would be frustrating if you were new users or on a time crunch

Prompt: How did the layout of the whiteboard affect your ability to communicate?

A1-2

I was confused at first as to where the text would go. But then I didn't care as long as I was communicating. The layout wasn't too busy. It would have been hard for me if there had been a lot of extraneous stuff.

B1-2

The tools were easy to manipulate. I thought at first that Julia had control and I didn't. Once I got the text to type I relaxed.

A2-2

Well it was very difficult-impossible without at least written language. With writing and then speaking it was as if the person was in the same room and was showing a solution.

B2-2

The screen size at times could have been bigger and I would have been more intelligent if I had zoomed out.

A5-2

As an artist I yearned for more sophisticated tools although other users might find them overwhelming. If no audio is available, I'd prefer a chat type area. My partner and I

created a system as we worked.
B5-2
We had to negotiate areas of assigned input when I got sloppy.
Sometimes I couldn't decide whether to write or draw.
A6-1
The layout is fine.
B6-1
It got easier the more I did it.
A7-2
As far as layout, the design was easy to navigate + was standard to most drawing tools.
Except for the undo.
B7-2
It was ok.
A8-1
I thought it was useful, but after seeing the videotape I thought I understood, but I completely froze up.
B8-1
I liked it and would have liked a board with rotation options.
A9-1
Being affected by the remote users zoom levels made it easy to lose the train of thought when drawing.
B9-1
Tools were in standard position, so were easily found.
A10-1
There was enough information to communicate with one another but when one doesn't see or hear the other one, it makes it difficult.
B10-1
It interrupts the flow of language.
Component are broken down.
White board is confining to basic step-baby steps
They flow together in face-to-face interaction.
A12-1
Not at all. It was a std paint layout so we were used to it.
B12-1
I don't think it had much effect.
A13-2
The text needed to wrap around earlier - it was a nuisance to keep moving the screen. Otherwise it was pretty straightforward.
B13-2
At first it caught me off guard. While I continued to use it, the whiteboard excercise actually became fun.
No real problems with the layout.
Easy to use & understand.
A14-2
It would be nice to have a chat box, or designated typing communication area. Text

appearing just wherever caused difficulties.
B14-2
I would have needed more time to get to know the menu choices. I rarely use this kind of program. But it was simple … communication was easy.
A15-2
I had a difficult time with space, especially when using text only as communication. Our words were typed on top of each other + the whiteboard space got messy.
B15-2
Without a “writing” area or “drawing” area it took a few minutes until we came up with our own guidelines and then we moved along quite well (I thought)
A16-1
Not a whole lot.
B16-1
Bigger screen, snap tools, some AutoCad LT stuff would have improved quality would have improved quality – but we were not typing to create a product – solving problem
A17-2
The layout was fine. It was my lack of ability to utilize the tools that was the problem.
B17-2
It seemed natural given other computer-based tools I have used.
A18-1
Getting used to this form of communication –
it is advanced e-mail – graphic interface –
that did take a little time to adjust –
I preferred drawing to typing!
B18-1
The layout was Fine. The whiteboard had plenty of space + all the tools were neatly grouped together.
A19-1
It made communication quite simple. The tools such as text, color etc. made it easy to place the objects and communicate where the objects should be.
B19-1
Controlled it – but only initially – once you established a pattern of communication you were pretty free to do what you choose to communicate
It’s rudimentary for sufficient (ends abruptly)

Prompt: What did your partner do that was effective in communicating with the whiteboard?

A1-2
Yes. He did well at typing and drawing enough to get the idea across.
B1-2
Using text was very helpful. I got the idea to use straight lines instead of freehand drawing from her just by watching.
A2-2
He used the pointer and imitated how to draw the object.

B2-2

Using the pointer and the cursor to demonstrate what we were to do.
Audio made it easier because it was a familiar language although the other tools worked.

The text worked well when we had no communication.

A5-2

My partner drew the most important parts letting me build on this. She also used humor to enliven the process.

B5-2

Typing created a problem when it did not wrap around, when it would not activate the position cursor so I could start. I found that once I realized I would have to return at end of screen it was better. A separate text area would be easier.

A6-1

Drawing the pieces where they should go + showing the right direction where to face the pieces.

B6-1

A good job at drawing the shapes.

A7-2

Described what the components of drawing were.

Drew placement of shapes.

Gave description + definition.

B7-2

Spoke to me or typed a message.

A8-1

She was effective in telling me in non audio how to break up the puzzle.

B8-1

Copying the original & drawing white lines to indicate the shapes was extremely helpful.

A9-1

Text and drawn descriptions made communication more understandable.

B9-1

Drawing the pieces by starting at one point.

A10-1

He began typing in directions or drawing it first & then erasing it to see if I responded the correct way.

B10-1

Ok during verbal not great but we were ineffective in our written explanation lost (two or three unintelligible words) communicate.

A12-1

Talk and write when unsure. - we set rules prior to going to WB only enviornment.

B12-1

used colored lines like the red to point out the two identical triangles in different places.

A13-2

I guess the mixture of text -- drawing. Clearing off the old stuff seemed to help a bit. The primary problems weren't "what was the shape made out of" but how to get the hang of the tools, etc. of course the audio part helped a lot.

B13-2

She typed messages on the screen and I would respond.

A14-2

She communicated primarily in text

B14-2

Drew pictures when I didn't understand his written responses and vice a versa.

A15-2

His drawings were clear and easy to follow. Once he did a problem with me he showed me exactly how it should be done the most efficiently. I really kind of “mucked about” in comparison.

B15-2

Drawing the shapes, talking through it once that was allowed.

A16-1

Type text and draw!

B16-1

Insist on drawing Vs talking – visual input faster more thorough

Learned to draw lines contiguous to ease shape creation.

A17-2

Drawing the pieces

Labeling the pieces

B17-2

He used text to label the pieces

He drew. This helped overcome some of the limitations of the drawings.

A18-1

Draw – point – clarify –

He also gave good directions and feedback

The pointer was helpful to focus the attention

B18-1

Draw shapes quickly using lines, put a letter in them to signify its difference from similar shapes, and typed information that could not be conveyed through the shapes.

A19-1

My partner used the drawing and text tools, as well as color. In doing so, it made identification of the correct positioning possible.

B19-1

We established “ownership” fairly quickly of the whiteboard – this helped a lot. She asked questions when we had the chance

Prompt: What caused the most problems in communicating with your partner?

A1-2

The beginning. I wasn't sure about what I was supposed to do. The terms "problem" and "solutions" confused me - I thought we were going to do math problems. At first I forgot there was someone else on the other side who could help me understand what to do.

B1-2

I think just the initial confusion. Once we were typing to each other we sailed!

A2-

Not being very familiar with how to use the different options, not knowing how to start.

B2-2

Color-coded shapes. Drew carefully. Stayed on task.

A5-2

There is a split reality in this distance learning mode. It was a little difficult to keep track of both the puzzle pieces and the "conversation" on screen. There also wasn't a CB style "over" or "over and out" to convey a thread I thought was complete.

B5-2

"Interrupting" his "space" or not waiting to be sure that I was interrupting with us on the same track.

A6-1

Neither one of us can draw well.

B6-1

My not understanding what was going on.

A7-2

I didn't know exactly what to do. +
I didn't use the pieces given.

B7-2

Nothing . Didn't realize that we could use the File/Edit tools.

A8-1

Not understanding what to do.

B8-1

She didn't know she had physical puzzle pieces & I didn't realize it at first.

A9-1

Limitations of the tools, or more appropriately, having to hand draw most shapes.

B9-1

My own turning of the pieces around in my mind.

A10-1

Not being able to see the person when audio went off it made it even more difficult.

B10-1

Not being able to visualize what was said.
Lack of synchronicity between what I wanted done/her response. I was impatient
For me-creating meaning was difficult/artificial
No room to explain/expand whiteboard was confining

A12-1

taking turns we both wanted to lead.

B12-1

probably the verbal stuff! I think we got too absorbed in discussing the picky stuff.

A13-2

The clutter of the text and stuff. Um, there wasn't a context in which non-verbal (physical) cues were necessary.

B13-2

I didn't understand what I was supposed to do at first, so we communicated a lot by typing and trying to figure the solutions out.

A14-2

Text placement and a need to explain not to type off the end of the screen.

B14-2

I don't believe there were any problems. I had some difficulty understanding and manipulating the text in the box & locating the box in a good place (lack of familiarity)

A15-2

Spacial* confusion. Making mistakes + wanting to start over but not being sure what to erase (it was shared space)- I went to another page to work!

B15-2

Confusion over writing space. We typed over ourselves at first.

A16-1

She seemed more glued to the screen – and I sensed that she wasn't manipulating the pieces to try to reach the solution on her own.

B16-1

I insisted on trying to talk instead of draw

A17-2

Using a line that was far too thick. Once I changed the width of the line it made the drawings more clear.

B17-2

There was one delay when I didn't know what he was doing after I finished the drawing.

A18-1

My typing – also spacial* awareness on my end – (tangrams are not my strength!)

B18-1

Not being able to draw one set of shapes and group + rotate + copy from figure to figure (which we probably do in real life if we had many of these to do.) But when the audio dropped out the text kept things going pretty well.

A19-1

I felt that we had no problems communicating.

B19-1

Audio was difficult – lack of control of lines on my part

Getting the "control" flow down between us

Prompt: What interfered with understanding your partner?

A1-2

Nothing really. We did fine once we figured out what was going on.

B1-2

Nothing that I can think of.

A2-2

At first not knowing how to start, who would start and honestly what to do. Lack of language.

Written was better and audio made it very easy.

B2-2

Finding common language understandings such as pointing, shadowing (movement of cursor). textual cues, all because of being unfamiliar with each other's styles.

A5-2

It was harder to express ideas on "paper" than it was in real life. There is a substantive nature to drawing and typing that is less playful. No doubt this factor is what "forced" me to fix the typos. In conversation the tendency is to get it out and refine the concept later. Online, like writing seems less casual.

B5-2

Forgetting to watch the board. Changing goals: (doing this together + communicating it, or "giving" solution/"getting" solution.)

A6-1

Neither one of us can draw well.

B6-1

Same as above.

A7-2

My neglect to using the given pieces.

Forgot about them until the end.

B7-2

Nothing.

A8-1

Ability to want to talk.

B8-1

The to figure things out on my own prevented me from focusing on communication.

A9-1

I did not notice anything that interfered with understanding the other participant.

B9-1

Nothing I can think of.

A10-1

Not being able to have a hands on approach even though we could see what each one is doing.

B10-1

No face-to-face interaction

No real chance to establish a dialogue

Our language attempts at communicating were hindered by distance.

You have to do one thing at a time – look check confirm explain ..in person this is a lot quicker + so blur together

A12-1

nothing

B12-1

she kept using her mouse pointer to show me things until I told her to use the hand.

A13-2

My partner's denseness (just kidding)

Well, obviously not being able to see her. And not having a triangle tool.

B13-2

Nothing really interfered once we understood the problems. I believe we communicated effectively even though our drawing abilities were very poor.

A14-2

just the text placement again.

B14-2

My problems with visual perceptual skills!

And he was able to "talk" me through them.

A15-2

See above.

B15-2

Confusion with typing writing space.

A16-1

Her verbal description of the pieces without drawing them!

B16-1

Only once – lack of sufficient input (while verbalizing) to place parallelogram correctly.

A17-2

Being unfamiliar with how to draw on the whiteboard. This drew my attention away from my partner.

B17-2

Not being able to converse until the last screen.

A18-1

Nothing really –

He was clear and used multiple methods to get at my understanding of the problem

B18-1

Just our own hastiness, its almost impossible to convey a mental image as fast as you want to, and in that we made rotational mistakes.

Other than that, not having an autoscrolling “chat” area was annoying.

A19-1

None applicable

B19-1

Lack of precision in line drawing.

Appendix E

Group #___

Descriptive		Action		Highlight		Text		Audio		Comments
A	B	A	B	A	B	A	B	A	B	

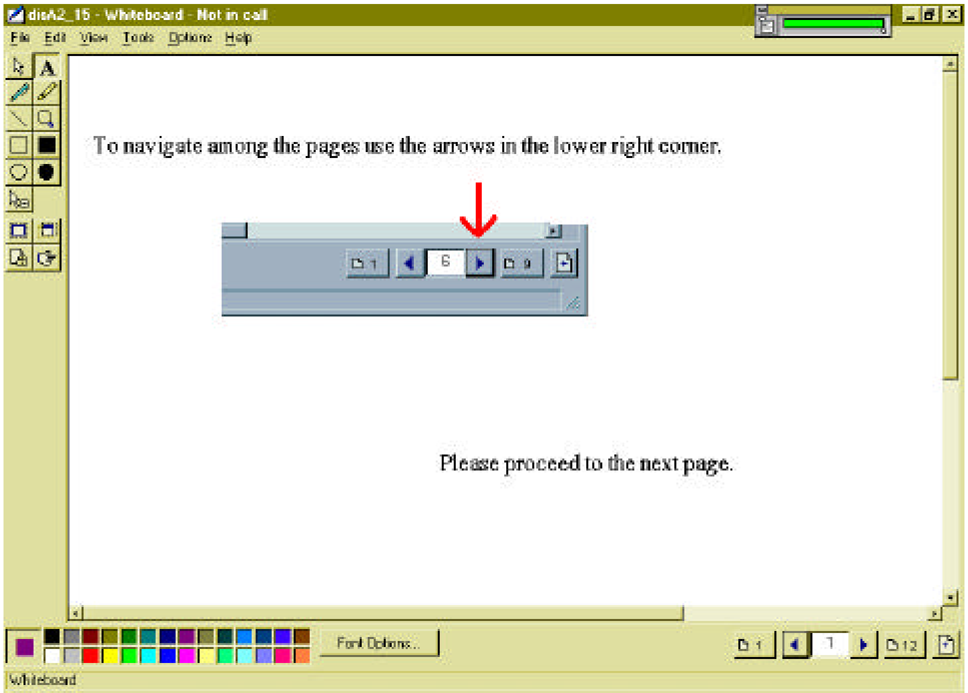
Appendix F

An example of the chart used to code events according to time.

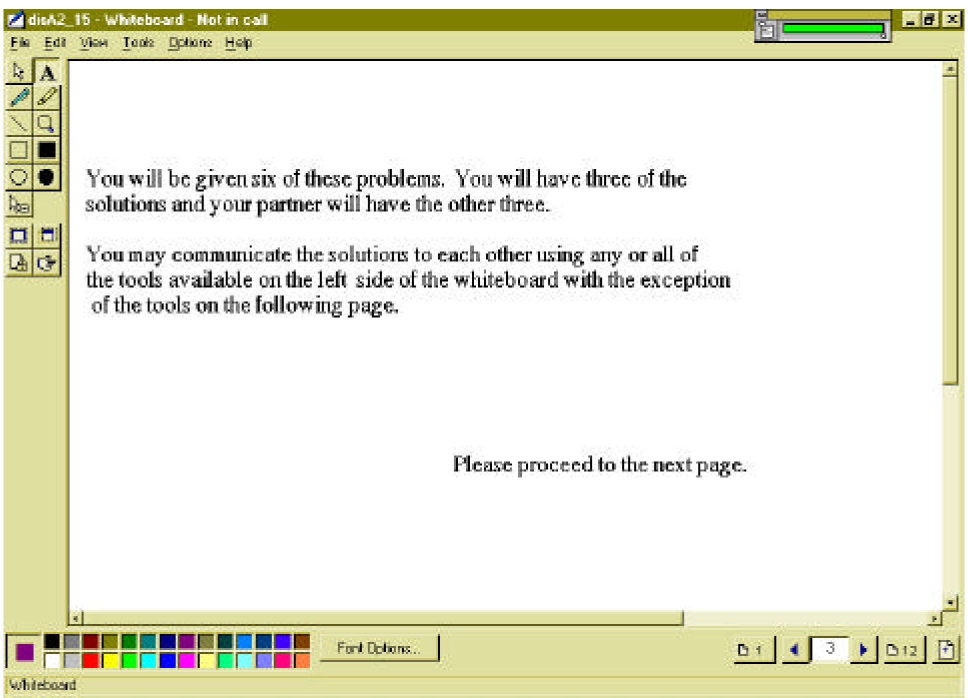
	Descriptive																							
	Action																							
A	Highlight																							
	Text																							
	Audio																							
	Descriptive																							
	Action																							
B	Highlight																							
	Text																							
	Audio																							

Appendix G

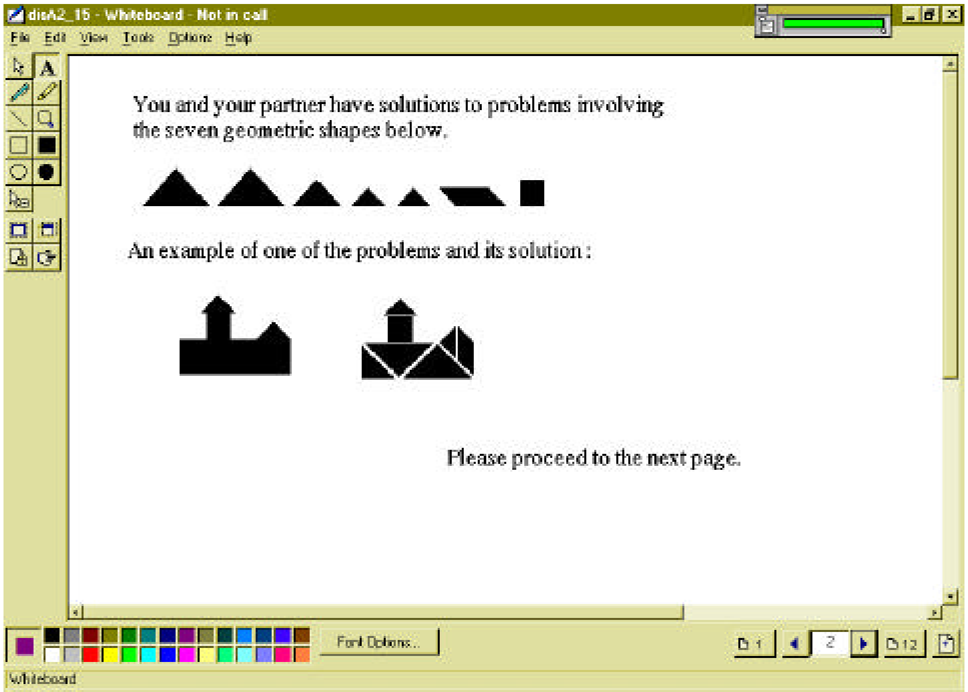
Screenshots of the first 4 slides.



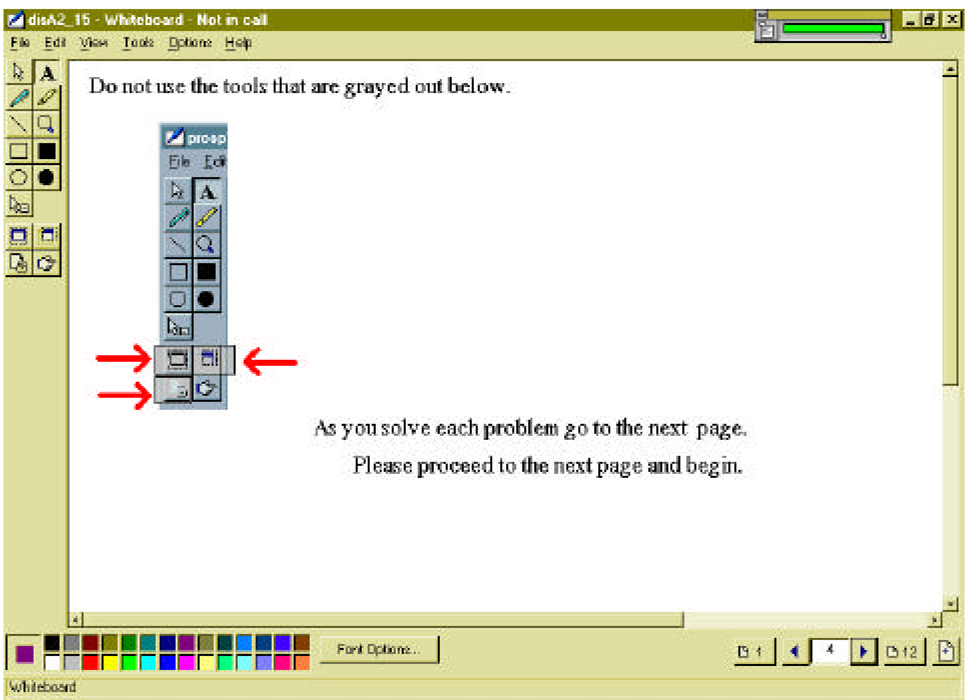
Screen 1



Screen 2



Screen 3



Screen 4

Appendix H

Table H1
Results of Self-assessed Computer Familiarity

Participant	WP	DP	Dr	Gr	Em	ID	CC	*M*	OF	*M* DF
A1	6	1	4	1	6	4	2	3.43	5	
B1	5	3	4	3	5	1	2	3.29	4	**3.36**
A2	6	1	3	1	7	1	1	2.86	4	
B2	6	6	3	3	6	1	1	3.71	5	**3.29**
A5	6	7	7	7	5	2	2	5.14	6	
B5	4	6	4	4	5	3	1	3.86	5	**4.50**
A6	5	1	1	1	1	1	1	1.57	4	
B6	2	1	1	1	1	1	1	1.14	2	**1.36**
A7	6	6	6	6	6	4	4	5.43	7	
B7	6	5	4	4	6	4	4	4.71	6	**5.07**
A8	7	5	4	4	7	1	1	4.14	5	
B8	6	5	1	3	3	1	1	2.86	5	**3.50**
A9	7	5	6	5	7	5	3	5.43	6	
B9	7	5	5	5	7	7	7	6.14	7	**5.79**
A10	5	2	2	2	5	2	1	2.71	4	
B10	6	4	5	3	6	3	6	4.71	5	**3.71**
A12	7	4	6	6	7	5	4	5.57	7	
B12	7	5	6	5	7	1	4	5.00	6	**5.29**
A13	6	3	2	2	6	1	1	3.00	5	
B13	7	4	2	2	7	5	4	4.43	5	**3.71**

table continues

Participant	WP	DP	Dr	Gr	Em	ID	CC	*M*	OF	*M* DF
A14	6	6	6	7	7	7	5	6.29	7	
B14	5	3	2	2	5	4	2	3.29	5	**4.79**
A15	6	1	4	5	6	5	1	4.00	5	
B15	6	4	5	5	6	2	2	4.29	5	**4.14**
A16	4	2	3	3	5	1	2	2.86	4	
B16	6	4	7	6	6	2	2	4.71	5	**3.79**
A17	5	1	1	2	7	1	1	2.57	5	
B17	5	4	5	4	7	3	3	4.43	7	**3.50**
A18	7	6	4	4	7	5	4	5.29	5	
B18	7	5	6	7	7	4	5	5.86	7	**5.57**
A19	6	5	3	5	6	6	6	5.29	6	
B19	7	5	4	6	7	3	2	4.86	5	**5.07**
								M	5.29	**4.1**
								SD	1.2	1.1

Note. OF = Overall familiarity with computers as self-assessed by the participant; *M* DF = Mean familiarity for the dyad; WP = Wordprocessing; DP = Desktop Publishing; Dr = Drawing; Gr = Graphics; Em = E-mail; ID = Interactive Discussions; CC = Computer Conferencing

Table H2

Results of Self-assessed Computer Familiarity for Audio Introduced Initially

Participant	WP	DP	Dr	Gr	Em	ID	CC	*M*	OF	*M* DF
A6	5	1	1	1	1	1	1	1.57	4	
B6	2	1	1	1	1	1	1	1.14	2	**1.36**
A8	7	5	4	4	7	1	1	4.14	5	
B8	6	5	1	3	3	1	1	2.86	5	**3.50**
A9	7	5	6	5	7	5	3	5.43	6	
B9	7	5	5	5	7	7	7	6.14	7	**5.79**
A10	5	2	2	2	5	2	1	2.71	4	
B10	6	4	5	3	6	3	6	4.71	5	**3.71**
A12	7	4	6	6	7	5	4	5.57	7	
B12	7	5	6	5	7	1	4	5.00	6	**5.29**
A16	4	2	3	3	5	1	2	2.86	4	
B16	6	4	7	6	6	2	2	4.71	5	**3.79**
A18	7	6	4	4	7	5	4	5.29	5	
B18	7	5	6	7	7	4	5	5.86	7	**5.57**
A19	6	5	3	5	6	6	6	5.29	6	
B19	7	5	4	6	7	3	2	4.86	5	**5.07**
								M	5.2	**4.3**
								SD	1.6	1.5

Note. OF = Overall familiarity with computers as self-assessed by the participant; *M* DF = Mean familiarity for the dyad; WP = Wordprocessing; DP = Desktop Publishing; Dr = Drawing; Gr = Graphics; Em = E-mail; ID = Interactive Discussions; CC = Computer Conferencing

Table H3

Results of Self-assessed Computer Familiarity for Audio Introduced Latter

Participant	WP	DP	Dr	Gr	Em	ID	CC	*M*	OF	*M* DF
A1	6	1	4	1	6	4	2	3.43	5	
B1	5	3	4	3	5	1	2	3.29	4	**3.36**
A2	6	1	3	1	7	1	1	2.86	4	
B2	6	6	3	3	6	1	1	3.71	5	**3.29**
A5	6	7	7	7	5	2	2	5.14	6	
B5	4	6	4	4	5	3	1	3.86	5	**4.50**
A7	6	6	6	6	6	4	4	5.43	7	
B7	6	5	4	4	6	4	4	4.71	6	**5.07**
A13	6	3	2	2	6	1	1	3.00	5	
B13	7	4	2	2	7	5	4	4.43	5	**3.71**
A14	6	6	6	7	7	7	5	6.29	7	
B14	5	3	2	2	5	4	2	3.29	5	**4.79**
A15	6	1	4	5	6	5	1	4.00	5	
B15	6	4	5	5	6	2	2	4.29	5	**4.14**
A17	5	1	1	2	7	1	1	2.57	5	
B17	5	4	5	4	7	3	3	4.43	7	**3.50**
								M	5.4	**4.0**
								SD	0.9	0.7

Note. OF = Overall familiarity with computers as self-assessed by the participant; *M* DF = Mean familiarity for the dyad; WP = Wordprocessing; DP = Desktop Publishing; Dr = Drawing; Gr = Graphics; Em = E-mail; ID = Interactive Discussions; CC = Computer Conferencing.

Table H4

Number of Events According to 10-Second Intervals

	Descriptive		Action		Highlight		Text		Audio	
Dyad	A	B	A	B	A	B	A	B	A	B
1	33	26	10	0	4	0	35	16	6	10
2	69	74	36	41	14	20	99	81	37	17
5	25	24	6	3	0	2	65	33	28	28
6	67	49	10	11	4	0	7	4	96	102
7	87	28	5	5	0	1	11	22	18	20
8	65	40	16	21	6	3	0	3	119	102
9	23	15	0	3	0	2	5	4	36	39
10	88	70	23	26	5	12	40	28	223	211
12	81	42	38	20	8	12	22	12	174	150
13	43	30	16	9	5	2	44	39	36	40
14	24	3	4	3	3	0	34	33	19	19
15	33	23	4	2	6	9	31	23	23	25
16	29	14	4	6	4	2	1	2	89	96
17	34	22	1	2	7	16	10	14	20	26
18	22	25	7	5	18	20	9	14	77	76
19	27	25	7	6	2	11	11	6	80	77
Subtotal	750	510	187	163	86	112	424	334	1,081	1,038
Total	1,260		350		198		758		2,119	

Note. Column headings A and B refer to participants A and B.

Table H5

Number of Interactions

Participant	D	Ac	H	T	Au	Total D	Total Ac	Total H	Total T	Total Au	I	Time
A1	8	9	2	12	9							
B1	12	1	1	8	10	20	10	3	20	19	72	1,600
A2	49	31	8	46	23							
B2	37	38	13	34	15	86	69	21	80	38	294	4,700
A5	19	3	0	50	26							
B5	28	7	1	35	27	47	10	1	85	53	196	1,600
A6	48	10	0	6	86							
B6	29	7	0	2	91	77	17	0	8	177	279	2,900
A7	39	6	0	5	28							
B7	21	2	1	11	27	60	8	1	16	55	140	1,500
A8	86	16	9	1	110							
B8	40	21	14	1	103	126	37	23	2	213	401	2,400
A9	36	0	1	4	39							
B9	18	2	0	4	42	54	2	1	8	81	146	600
A10	98	27	4	19	353							
B10	73	24	11	22	348	171	51	15	41	701	979	3,800
A12	91	38	21	14	185							
B12	39	8	15	8	178	130	46	36	22	363	597	3,200
A13	39	13	4	30	44							
B13	14	0	3	31	46	53	13	7	61	90	224	1,800

table continues

Participant	D	Ac	H	T	Au	Total D	Total Ac	Total H	Total T	Total Au	Total I	Time
A14	18	4	1	20	31							
B14	5	6	0	22	29	23	10	1	42	60	136	1,200
A15	25	5	0	18	29							
B15	20	2	15	9	28	45	7	15	27	57	151	1,500
A16	38	5	0	1	109							
B16	11	6	4	3	97	49	11	4	4	206	274	1,600
A17	19	1	4	6	17							
B17	13	2	19	10	20	32	3	23	16	37	111	1,400
A18	38	6	18	9	108							
B18	32	11	19	10	98	70	17	37	19	206	349	1,300
A19	25	9	3	5	55							
B19	19	7	13	8	62	44	16	16	13	117	206	1,300
					Total	1087	327	204	464	2,473	4,555	
						Graphics Total		1,618	T&A Total	2,937		

Note. D= descriptive events; Ac = active events; H = static highlight events; T = text was entered; Au = audio was used; I = interactions; time is in seconds.

Table H6

Number of Interactions by Type

	Participant	P	O	A	C	E	U	M	L	H	Subtotal	Total
Action	A1					3		3			6	
	B1					1					1	7
Highlight	A1			1					1		2	
	B1								1		1	3
Action	A2	14				16	2				30	
	B2	14				20					34	64
Highlight	A2										4	
	B2							1			7	11
Action	A5			1						3	1	
	B5					6		1			7	8
Highlight	A5										0	
	B5				1						1	1
Action	A6					10					10	
	B6					7					7	17
Highlight	A6										0	
	B6										0	0
Action	A7					4					4	
	B7					6		1			7	11
Highlight	A7										0	
	B7			1							1	1

table continues

	Participant	P	O	A	C	E	U	M	L	H	Subtotal	Total
Action	A8					10		6			16	
	B8					14	4	3			21	37
Highlight	A8	8		1							9	
	B8	4		8	2						14	23
Action	A9										0	
	B9					2					2	2
Highlight	A9			1							1	
	B9										0	1
Action	A10					26					26	
	B10					21	3				24	50
Highlight	A10	2								2	2	
	B10	1		7	1				3		12	14
Action	A12		3			26	3				32	
	B12		1			7					8	40
Highlight	A12	17		3							20	
	B12	15							1		16	36
Action	A13		3			27	4				34	
	B13		1			7					8	42
Highlight	A13	14		4					1		19	
	B13	15							1		16	35
Action	A14					2		2			4	
	B14					4	2				6	10

table continues

	Participant	P	O	A	C	E	U	M	L	H	Subtotal	Total
Highlight	A14			1							1	
	B14										0	1
Action	A15					5	1				6	
	B15					2					2	8
Highlight	A15										0	
	B15								15		15	15
Action	A16					5					5	
	B16					5	5				10	15
Highlight	A16										0	
	B16	1							3		4	4
Action	A17					1					1	
	B17					2					2	3
Highlight	A17								4		4	
	B17			9					8		17	21
Action	A18	2						3			5	
	B18	1		4		3	3				11	16
Highlight	A18	14							4		18	
	B18	9		5					4		18	36
Action	A19							8			8	
	B19				1	6					7	15
Highlight	A19	1			2						3	
	B19			2	5				5		12	15
	Totals	132	8	48	12	248	27	28	51	5		562

Note. P = pointer; O = outline; A = arrow; C = circle; E = erase; U = undelete; M = move; L = label; H = highlight .

Table H7

Non-descriptive Uses of the Whiteboard with Percentage of Motion Related Activities

Dyad	Activity	Total	Action as a % of Motion Related Activity
1	Action	7	70.0%
	Highlight	3	
2	Action	64	85.3%
	Highlight	11	
5	Action	8	88.9%
	Highlight	1	
6	Action	17	100.0%
	Highlight	0	
7	Action	11	91.7%
	Highlight	1	
8	Action	37	61.7%
	Highlight	23	
9	Action	2	66.7%
	Highlight	1	
10	Action	50	78.1%
	Highlight	14	
12	Action	40	52.6%
	Highlight	36	
13	Action	42	54.5%
	Highlight	35	

table continues

Dyad	Activity	Total	Action as a % of Motion Related Activity
14	Action	10	90.9%
	Highlight	1	
15	Action	8	34.8%
	Highlight	15	
16	Action	15	78.9%
	Highlight	4	
17	Action	3	12.5%
	Highlight	21	
18	Action	16	30.8%
	Highlight	36	
19	Action	15	50.0%
	Highlight	15	

Appendix I

Pilot Study Summary

The pilot study consisted of 4 dyads. The participants were graduate and undergraduate students at Virginia Polytechnic Institute and State University. The first two dyads had 2 experienced computer users each. The third dyad had an experienced computer user and a novice computer user. The fourth dyad had 2 novice computer users.

The dyads engaged in the same activities described in Chapter 2 and the interaction within the whiteboard was recorded through a scan converter connected to one of the computers to a video tape. The participants in the first dyad were also videotaped. The first dyad did not have an audio system for communication and were situated in a way that they were able to converse naturally. The first dyad's experiences led to changes in the whiteboard screens used for the activities a well a changing the setting. The videotaping was deemed an unnecessary distraction for the study's objectives and was not employed for the other dyads. The other dyads were isolated according to the setting in Figure 7 in Chapter 2.

All pilot study dyads began without audio for the first 4 activities and were able to use audio for the last 2 activities. None of the dyads used text when audio was available. The total time for all 6 activities ranged from 1,260 seconds for dyad 4, 1,380 seconds for dyad 3 and 2,640 seconds for dyad 2.

Exit interviews were used to determine minor changes in procedure for the final study. The pilot study participants were positive in their remarks. All of the dyads preferred audio, commenting that it was faster (dyad 2) and easier (dyad 3). The interactions and use of the whiteboard tools were consistent with results in the final study.

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Vita

Carmel John Vaccare

Educational Work Experience
Assistant Professor of Electronics, Southside Virginia Community College, Alberta, Va.

Sample of Additional Work Experience (1970-1980)
Corporate Officer, Southside Ambulance Services, Blackstone Va.
Psychiatric Aide, Piedmont Geriatric Hospital, Burkeville, Va.
Lathe & Saw
Operator and Factory Mechanic, Cellar Creek Handle Factory, Blackstone, Va.
Factory Mechanic, Craddock-Terry Shoe Corporation, Blackstone, Va.
Theater Manager, Farmville Drive-In & State Theater, Farmville, Va.
VISTA, Central Piedmont Action Council, Cumberland, Va.

EDUCATION

1995 -1997	Ph.D. in Teaching and Learning, Instructional Systems Development Virginia Polytechnic Institute and State University, Blacksburg VA.
1987-1989	M.S. in Mathematics Virginia State University, Petersburg, Va.
1983-1984	B.S. in Electronics Engineering Technology Virginia State University, Petersburg, Va.
1980-1982	A.A.S. in Electronics Technology Southside Virginia Community College, Alberta, Va.
1973-1974	Welding Certificate Southside Skill Center, Crewe, Va.
1969-1970	Fine Arts Curriculum Silvermine College of Art, New Canaan, CT.
1968	Liberal Arts Curriculum Fairfield University, Fairfield, CT.

Educational and Professional Activities
Graduate Assistant, Appalachian College Association, Virginia Tech (1996 – 1997)
Graduate Assistant, Center for Excellence in Undergraduate Teaching, Virginia Tech (1995-1996)
VCCS Leadership Conference (1993)
Virginia Master Teacher Conference (1994)

Professional Organizations
American Educational Research Association (AERA)
Association for Educational Communications and Technology (AECT)
International Visual Literacy Association (IVLA)
Piedmont Council of Teachers of Mathematics (PCTM)
The Virginia Society for Technology in Education (VSTE)

Presentations
Eastern Educational Research Association Conference (1995)
Association for Educational Communications and Technology (1997)
VCCS New Horizons Conference (1994, 1995, 1996, 1997)