Multiple Display Environments in meeting spaces: insights from field and laboratory studies

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ABSTRACT

In this document, I present longitudinal research investigating multi-display environments (MDE) in collaborative settings over an eight-week period at two companies. I also present preliminary laboratory research results exploring the effects of increasing shared pixel spaces within a collaborative meeting environment and its effect on performance, collaboration, and satisfaction with the meeting process. This research seeks to explore whether increasing shared pixel spaces contributes to a better comprehension of the meeting, or serves as a distraction or additional element competing for attention resources.

INTRODUCTION

Collaborative spaces are becoming more like "war situation rooms" with multiple displays, devices, and individuals. As such, they are multi-display environments (MDEs), where displays can be both shared, such as a room-based LCD projector, or individually-owned, such as an attendee's laptop computer. In this document, I present longitudinal and laboratory studies investigating the impact of increasing the amount and position of large, shared displays within meeting environments. Preliminary findings from both studies are presented, including evidence for subtle changes in how groups collaborate when using multiple shared displays. In addition, I present evaluation criteria for collaborative MDEs based upon previous work performed on collaborative group decision-making processes.

MULTI-DISPLAY ENVIRONMENT THEMES

The research presented in this document touches upon several themes including creating design guidelines for MDE systems, understanding the types of group activities that benefit from MDEs, as well as contributing towards development of evaluation metrics for MDEs within collaborative environments.

Motivation

MDE prototype research often evaluates specialized technologies in collaborative spaces, for example the Stanford Interactive Workspaces project [6] and Biehl's IMPROMPTU [1] system both focus on the integration of software and display technologies. Conversely, the management information systems community studied a wide variety of group decision support systems (GDSS) [eg 2,3]. These systems are specialized software to support the decision-making process, and emphasis of this research is on the software and not the shared displays within the collaborative environments

Much research in this area focuses on the *how to* of displaying information in a space; my research seeks to explore how additional shared screen real estate *changes meeting dynamics*. In this age of widespread wireless Internet connections allowing for access to information via mobile devices, how can additional shared displays impact the meeting process? Do display act as mechanisms that increase the amount of information available to attendees, or do they serve as a distraction? Does increasing the shared pixel space facilitate participation or better comprehension of the main meeting topic? Or do such displays simply become additional items competing for scarce attention resources?

To further understand the implications of increasing shared pixel spaces within meeting environments, it is important to understand when technology devices are brought into real-world meeting spaces. For example, when are these devices used to share information with others and when are they connected to shared displays?

To investigate the research questions posed above, I conducted field studies and controlled laboratory studies, and as a result, employed both quantitative and qualitative evaluation. Furthermore, findings from the initial field study have been used to inform the experimental design of the controlled laboratory study, as discussed in the following sections.

Longitudinal Study

The purpose of this longitudinal study was to investigate existing display and device usage within two "authentic" meeting environments at two companies as well as to record changes to work practices when a second shared display was introduced within each space. Over an eight-week period, I observed meeting space usage as well as conducted interviews with company employees. I collected statistics on both digital and analog device usage, personal and shared equipment usage, as well as which devices were connected to displays.

Halfway through the observation process, I placed a second large, shared display within each meeting space as a technology probe to examine how individuals reacted to and/or used the additional pixel space. I recorded interaction and usage with technology within the spaces and conducted follow-up interviews about participants' experiences within the meeting spaces.

Specific findings of interest include the proliferation of laptops being brought into meeting spaces for having information ready for retrieval during the meeting. Individuals in one space also treated their environment as a "war room" and frequently made use of wall space to keep static information prominently displayed within the environment. When the second display was added into this collaborative space, individuals would sometimes use it as a reference display while main content was shown on the other display.

Other findings include an expressed preference for physical interaction with devices versus software-based interaction. In addition, a common "arming" ritual frequently occurred across both observed meeting spaces where electrical, peripheral, and video connections were made in the first few moments of an individual arriving into the space. This ritual appeared to be part of a larger social construct of transitioning into the meeting environment. Considering this existing lightweight practice may be important in designing interaction with MDEs in collaborative spaces to ensure successful deployment in real world situations.

In addition, both observed populations were part of international organizations with offices, plants, and suppliers located across the world. Several mixed-presence meetings were observed using a large display within the meeting room. During some of these meetings, commercial remote meeting software malfunctioned and individuals were observed through their troubleshooting, diagnosis, and recovering procedures. On several occasions, software solutions were abandoned in favor of makeshift sharing solutions, such as emailing files or placing files on a shared network drive and using a traditional conference phone.

Laboratory Study

To further investigate the impact of multiple shared pixels spaces on performance, collaboration, and satisfaction of the meeting process in controlled setting, I conducted a laboratory study. Designing controlled laboratory evaluation techniques for meeting situations is inherently challenging due to the mix of people and motives, however this situation was designed to resemble a reasonably authentic scenario encountered in typical meeting situations.

In each session, six participants were tasked to solve a problem where a company's sales were increasing but net profits were decreasing steadily (based on a scenario from [5]). This type of group problem is classified as "intellective" in nature by McGrath[7], meaning a correct solution was obtainable from the information provided. Each participant was given a laptop computer and information that the others did not have, requiring information to be shared to successfully solve the problem at hand.

The meeting space consisted of a conference table, chairs, white board, and a video matrix switch connected in one of three shared display configurations: single display, dual side-by-side on the wall, or independent displays placed at each end of the table. These configurations were selected to investigate not only the effects of increasing the number of shared pixel spaces, but also to explore the effect of display location.

Informed from interviews during the field studies, the interaction technique to share content on one of the large displays was a physical control button rather than software-based. Participants often remarked a physical interaction was easier to learn as well as troubleshoot.

Experiment sessions were evaluated along several metrics including performance, collaboration, and satisfaction. These metrics were measured using both qualitative and quantitative methods, such as conducting interviews, surveys, counting gestures, analyzing slide use, and recording/coding the decision-making process.

Preliminary findings show an increase in self-rated satisfaction for the overall meeting process for individuals in multiple display conditions over single-display as well as an impact on physical gesturing towards displays in MDEs. Most groups across all display conditions were able to sufficiently solve the problem presented. However, qualitative findings illustrate subtle changes in the dynamic and tone of meetings under each display condition.

DISCUSSION

The studies described in the preceding sections provide insight into design and evaluation of MDEs in authentic collaborative spaces. The field studies provide evidence suggesting the importance of reliability and physicality for MDE designers. When dealing with technological glitches, the studied populations' *only* troubleshooting step was to restart the computer and software applications. Several interviewees remarked that they gave up on using videoconferencing to remotely collaborate because it would fail too frequently and disrupt the meeting process.

Designing reliable and robust MDE systems needs to be a priority for adoption within real world organizations where users are not computer science degree holders.

MDE designers for collaborative spaces also should take into account existing work practices and rituals when designing systems. The aforementioned ritual of "arming" was observed across both meeting spaces, hinting that this ritual is a common and important component in the meeting workflow pattern.

The longitudinal study described earlier informs evaluation techniques for MDE systems. Evaluation of MDE systems is inherently difficult in collaborative environments, and I present experience developing metrics for evaluating usage under controlled laboratory conditions. Preliminary findings show that simply increasing the number of shared displays within a meeting space impacts how a meeting functions. Further examining this phenomenon may be useful in interpreting the impact of more sophisticated MDE systems within collaborative environments.

Finally, it should be noted that the management information systems community extensively studied group decision support systems (GDSSs) in the 1980s, developing technology-based solutions to facilitate meetings and collaboration. Fast-forwarding to 2008, it is not clear whether such systems have reached adoption at any substantial rate. Instead, it appears, that the proliferation of powerful mobile devices with internet connections is influencing how information is retrieved and shared during meetings—becoming *less* centralized and thus distributed across multiple devices. Therefore, it appears that MDE within collaborative spaces will increase in adoption as more devices contain information that needs to be shared with a larger audience.

However, the body of literature pertaining to GDSS systems offers additional insight into evaluation metrics that can easily be extended or adapted for use in evaluating MDE collaborative environments and warrants discussion. The evaluation metrics presented in the controlled laboratory study of performance, collaboration, and satisfaction, were extended from metrics presented within [2]. Furthermore, MDE designers for collaborative spaces may benefit from existing large display work, such as [4].

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