Defining, Measuring, and Improving Collaboration though Evaluating the Cornell Library Collaborative Learning Computer Laboratory

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ABSTRACT

This paper addresses the following three-part question: how do we define, measure, and improve collaboration? We examine these concepts with a case study of the Cornell Library Collaborative Learning Computer Laboratory. In evaluating the classroom, we ask "Does the (CL)3 room facilitate collaboration?" This question is important for the Human-Computer Interaction community since the vast majority of research into Computer-Mediated Collaborative Learning focuses on group collaboration across networked computers or different physical locations. In this paper we test the effectiveness of CMCL principles for both evaluating collaborative learning in a common physical location, and for suggesting ways to encourage greater collaboration in the same space.

INTRODUCTION

Background

Decades of research attest to the importance of user collaboration in learning environments. In a Computer-Mediated Collaborative Learning literature review by Hiltz et al [2], the authors present previous research which indicates the benefits of collaborative work. The CMCL community largely agrees that collaboration helps individuals learn better by both encouraging individuals to navigate through complex or new tasks, and providing gratification by increasing motivation and satisfaction with the learning process in general. It was with this research in mind that Cornell University set out to design the Cornell Library Collaborative Learning Computer Laboratory, also known as (CL)3. Cornell is one of the first academic institutions in the world to attempt to build a computer laboratory with the sole purpose of fostering collaboration.

Laboratory Design

The Cornell Library Collaborative Learning Computer Laboratory contains two whiteboards, eight workstations separated into two clusters, two tables, a projector and automatic drop-down screen. A ninth workstation is located in an elevated corner of the room beside the entrance. The workstations feature one CPU, two mice, two keyboards, and adjustable dual-monitors. Additionally, all workstations are completely mobile due to their wireless internet connections and portable battery supplies (Figure 1).

The lab has been in operation for over a year, both for public use and group-based classes such as an Introductory Programming Workshop (CS100J AEW) and Game Design (CIS300 and CIS490/790). We set out to evaluate the plan's execution.

Research Question

The high-level research question for this paper is the following: How do we define, measure, and improve collaboration? We will answer this question through our evaluation of the Cornell Library Collaborative Learning Computer Laboratory. Of specific interest to this study is whether the (CL)3 room facilitates collaboration. In order to answer the research question "Does the (CL)3 room facilitate collaboration," we must define the behavior, determine its indicators, and how to measure them. Finally, we will compare the results with (CL)3 user attitudes and behaviors in order to inform the design decisions which aim to improve collaboration in the laboratory.

EVALUATION

Defining Collaboration

In order to defining collaboration, we consulted a paper by Dillenbourg [1] which divides the term into collaborative situations, interactions, and processes. According to his research, one must first specify their category of interest in order to measure the effect of collaboration. For our study, we examined all three aspects of collaboration by administering a series of surveys, questionnaires and observation exercises to a range of user groups related to the (CL)3 room. We were concerned with both user attitudes and behaviors. Our participants included casual laboratory users, classroom students, and laboratory operators. In terms of public use, we were interested in the frequency of behaviors such as the utilization of classroom technologies, workstation operation, and patterns of group cooperation.

To compile survey data on casual users, we recruited laboratory operators. Operators supervise the laboratory during unstructured public use. The operator desk is

Figure 1. Workstations and Operator Desk in (CL)3

positioned at the same level as the two workstation clusters and provides an unobstructed view of the floor (Figure 1). We were inspired by an earlier HCI study which utilized the covert observations of security guards to uncover interesting data on museum patrons [6]. The survey was administered over the period of nine days. The unique perspective of operators proved to be the most valuable data source for collecting behavioral information on public users.

In addition to public users, we were also concerned with the behaviors of individuals who use the laboratory in a structured class setting. Presently, there are two kinds of courses taught in the (CL)3 room. Our team is interested in the few dozen students who use the classroom for game design (CIS300 and CIS490/790) and introductory programming (CIS100J AEW). Specifically, we sought student feedback in the following areas: familiarity with the laboratory, the type of work they perform in (CL)3, the reasons they return to the laboratory, their attitudes and strategies regarding group work, as well as their overall satisfaction with the equipment in the classroom.

We administered the questionnaires once to each student via the laboratory's own computer interfaces. Due to our affiliation with both class instructors, recruiting participants was not difficult. We had the benefit of 100% participation for students enrolled in CIS300 (21/21), and over 30% for students in CIS490/790 (10/33). Additionally, we received responses from 6 CIS100J AEW students.

Measuring Collaboration

Dillenbourg [1] describes collaborative interactions as synchronous; working side-by side. To measure this behavior, we examined how users interact with the input tools at their workstations. Specifically, we observed (via operators) and inquired about patterns of keyboard and mouse use and the frequency of dual/simultaneous versus single/alternate input strategies. Collaborative situations are described as symmetric; working together towards a common goal. To measure these situations, we examined how users interact with the visualization tools at their workstations. For example, we observed and inquired about patterns of monitor use and the frequency of utilization of the dual-screen configuration. Finally, Dillenbourg [1] describes collaborative processes in terms of cognitive load; the division of task-level and strategy-level tasks. Collaborative processes also include self-explanation; the inclination of individuals to articulate concepts by communicating them to a group. To measure these behaviors, we examined how users formed groups. Specifically, our questionnaires inquired about whether class teams were self-selected or assigned by an instructor. Additionally, operators observed and we inquired about the patterns of shared-meaning tools such as whiteboards and the projector.

RESULTS

Survey and Questionnaire Data

In total, 38 students completed the class-based questionnaire. Of that number, the majority of responses (55%) were from students enrolled in the introductory game design class (CIS300). The average group size of respondents ranged between 5 and 6 students. About half of the class respondents (55%) self-selected their project group. According to our data, the groups do not tend to meet much outside of class time.

In terms of individual attitudes towards collaboration, students enjoy working with others 75% of time while simultaneously they feel they work better alone 64% of the time. This data suggests that working alone and collaboratively are not mutually exclusive. Our data also indicates no significant difference between the preferences of students to divide task as opposed to working together.

Regarding the equipment in the (CL)3, 45% of class users seem to use the whiteboards for tasks such as brainstorming and outlining. On the other hand, only 30% of class respondents took advantage of the workstations' mobile features, most doing so for tasks such as adjusting workspace comfort in group situations. The most common reason students gave for not moving the desks was "no need." All the class users indicated that they were aware that the desks are mobile, but some were uncertain if moving the workstations is permitted. Notable comments include "don't want to break anything" and "the current setup is ideal most of the time, not sure I'm allowed to."

While sharing workstations, group members tend to collaborate on tasks such as game design (39%) and programming (37%) and word processing (11%). On the other hand, when people work alone on the workstation, they tend to work on the graphics (65%) and programming (58%).

In terms of input cooperation, our data indicates that 60% of the students tend to put away one set of mouse and keyboard when seated with their partners. In addition, 46% of class users struggle the control of the mouse, 39% compete for keyboard control, and 72% utilize the dual monitor configuration.

Overall lab satisfaction among class users ranges from 87% to 74%. Students expressed higher satisfaction in terms of desk height, space, foot space, while they were less satisfied with laboratory software and cord placement. Interestingly, we found no correlation between whether a student is right handed or left handed and their preference for sitting on the left or right side of the workstation.

Over the 9 day observation period, laboratory operators observed no whiteboard activity and only once noticed a change in the location of workstation desks. During public hours, workstations were occupied single users 58% of the time, and group users for 16% of the time. About 25% of individuals using the laboratory worked at tables or with other non-workstation equipment in the lab.

For all the percentage data we described above, we first counted the frequency of the presence or instances that particular activities occur, and then calculate its percentage in terms of the 38 people group (Table 1). The scale of mean and standard deviation (Sdev) is from 1 to 7. We converted the mean by dividing by 7, yielding the percentage mean to get a numerical sense of the data (Table 2).

Frequency	0	1	2	3	4	5	6	7
%	3	24	18	13	16	8	8	11

Table 1. Frequency of Mouse Control Competition

Frequency	mean	Sdev	% mean
move keyboard	4.711	2.078	67%
struggle over mouse	3.237	2.072	46%
struggle over keyboard	2.737	1.996	39%
use of both monitor	5.053	2.289	72%
only one set	4.184	2.025	60%
move workstation	2.079	1.978	30%
use of whiteboard	3.184	2.051	45%
share files	1.605	2.249	23%
enjoy working in group	5.421	1.426	77%
work better alone	4.447	4.606	64%
Prefer divide tasks	5.395	1.424	77%
Prefer collaborate	5.184	1.136	74%
Software satisfaction	5.184	1.929	74%
Hardware satisfaction	5.816	1.919	83%

Table 2. % mean = (mean/7)

DISCUSSION

Improving Collaboration

Although each workstation in the (CL)3 lab features dual monitors, two keyboards, and two mice, users can only use the input devices individually since there is only one CPU at each desk. Consequently, the screen displays in (CL)3 are considered "Single Display Groupware" despite their dual monitor configuration. The main problem this model is that the users compete for the control of the input via the Share User Input face. The presence of dual keyboard and dual mice does not address this problem since they cannot operate simultaneously. Since the second monitor only provides extended screen space (as opposed to an independent user interface) we decided to apply the Single Display Groupware (SGD) model to the (CL)3 room. Unlike most research on the topic which focuses on remote collaboration, Bederson's SGD model [7] focuses on collaboration for users working physically close to each other. The paper indicates the benefits of SDG; that it enables collaborative interactions, peer-learning, peer-teaching, strengthens of communication skill, and reduces conflicts or confusion when multiple users attempt to interact with single application. The disadvantages described in the SDG model also applies to the CL(3) lab.

Competing for the control of input devices creates conflicts when users attempt simultaneous incompatible actions (since most of the current applications are designed for single-users), the low portability of the software, and the danger of less communication due to parallel working. Boyd established the idea of "fair dragging" happened when a user gains the "floor control" once the mouse is dragged. [8] To avoid the conflict of taking over floor control, we suggest that the lab should take the advantage of the LAN and WLAN network by implementing thin client or VNC software that allow screen sharing and multiple control of the computer. [9]

According to our data, classroom users regularly utilized whiteboards for brainstorming and outlining, yet laboratory operators never noticed public users taking advantage of these tools. In an empirical evaluation of CMCL, Alavi [3] found that such shared-meaning instruments are important for Constructive Knowledge; a process of active learning which promotes the acquisition, generation and analysis of knowledge. Furthermore, research by Soller [5] indicates the necessity for Social Grounding; a shared understanding of meaning. In order to encourage collaboration with the use of tools which support Constructive Knowledge and Social Grounding, we recommend (CL)3 provide whiteboard functionality at the level of individual workstations. This could be achieved by installing miniature whiteboards at each station. As a bolder approach, all workstation desks could be refinished with a whiteboard-like surface.

Our data also indicated that although all of the class-based users were aware of the mobile features of the workstations, some were unsure about whether they were permitted to change their desk's position. As a result, few students took advantage of this unique property of (CL)3. Likewise, operators observed users moving a workstation only once. According to a study by Underwood, collaborative learning works best when “[s]tudents…have the benefits of this mode of working made explicit.” [4] Accordingly, we assert that collaboration in (CL)3 would be enhanced if users better understood tools available. We feel users would be more likely to utilize the mobile workstation features if the laboratory were to feature signage alerting them to the room’s versatility, as well as permission to exploit it. These helpful reminders could take the form of colorful posters. As a bolder approach, workstation screensavers could feature animated diagrams which cycle though various desk cluster configurations.

Conclusion

So does the (CL)3 room facilitate collaboration? According to our findings, we would assert that some of the activity in the laboratory indicates collaborative interactions, situations, and processes. However, we have a number of design recommendations which might improve collaborative work in (CL)3.

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