ERGONOMIC ANALYSIS OF THE CORNELL LIBRARY COLLABORATIVE LEARNING COMPUTER LAB (CL^3)

Compiled by DEA 470 Class
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1. Introduction

The role of collaboration in the learning process roots deep within educational, workplace, and many other fields requiring work among people, cementing its importance in current research pursuits. Yet, perhaps due to its profusion, need and similarity with the concept of cooperation, the need for a single, precise and consistent definition for collaboration remains. Indeed, many synonyms exist for both cooperation and collaboration throughout literature and many more definitions exist attempting to segregate the nuances between cooperation and collaboration. Hathorn and Ingram (2002), for instance, state that cooperation transpires when people parcel work, dividing responsibilities individually to achieve a goal. Wessner and Pfister (2001, p.24) take a different stance defining cooperation as involving "two or more people who have the common goal of knowledge acquisition, are willing to share their knowledge and experience, and social interaction and communication centers on achieving these objectives". However, Hathorn and Ingram (2002), Johnson and Johnson (1998), Kaye (1992), Staarman, Krol and van der Meijden (2005), and Aiken, Bessagnet, and Israel (2005) use these elements to define collaboration stating that collaboration involves harmonized efforts working together, sharing and synthesizing ideas to accomplish a common goal in which the effect cannot be achieved by and is expressly different from that of individual work. Teaming with previous research, the current research followed this vein, exploring the affect dual monitors, keyboards and mice have on collaboration.

The topic of collaboration has invited much critical discourse, broadening from the parameters of physical proximity and face-to-face encounters to that of virtual environments and computer supported collaborative learning (CSCL) where peers can communicate virtually among computer stations. As such, much research has explored group formation, dialogue exchange, distribution of power and authority, and turn-taking within such virtual contexts (Wessner and Pfister, 2001). Virtual collaborative environments have their benefits and continue to gain success and popularity, yet face-to-face collaboration maintains strong collaborative power over that of the more removed and tangential virtual learning environments. This may pertain to the synchronicity of concurrent, in person interaction. Often, virtual environments provide asynchronous interaction where one person can have operating control over a project at a given time, leaving others less active participatory roles. While some software allows for 'what you see is what you get' synchronous capabilities for multi-user interfaces, this is largely limited to

wall-mounted computer displays and conference liveboards (Tandler, 2001; Stefik, Foster, Bobrow, Kahn, Lanning and Suchman, 1987). Further, Kreijns and Kirschner (2001) assert that virtual learning groups must compensate for the lack of real-time interface with others, ease of ad hoc sociability, and atmospheric qualities of space and time associated with face-to-face interactions. The problem exists in limiting interaction to virtual interchange without the ability to see gestures and to pick up other vital social cues (Kreijns and Kirschner, 2001). Recognizing the importance of physical proximity, this research seeks to analyze how physical affordances influence collaboration.

Social interaction, involving mutual trust and understanding, underpins successful collaboration, and a well-designed environment enables this dynamic. Wang and Blevis (2004), for instance, analyzed various orientations of information as used by industrial designers and found that people favored eye contact, sitting around a table rather that side by side proximity, as well as diversity in workspace utility. In their work analyzing landscape architects, Büscher, Kramp and Krogh, (2003) found that individuals widely relied on multitude of spaces, transitioning from paper workspaces, to larger public computer displays, to more individual technology (Büscher, Kramp and Krogh, 2003). The original intention of the Cornell Library Collaborative Learning Computer Laboratory (CL^3) proposal submitted in 2001 sought similar versatility in design, recommending space, privacy and furniture flexibility" (Schwartz, 2001). Indeed, physical affordances, such as round tables, moveable seating, mobility in work, workspaces for various sizes of groups, and areas that support ranges of privacy are fundamental for supporting teamwork and collaboration (Luff and Heath, 1998).

Versatility in technology works in a similar fashion. Ubiquitous computing or pervasive technology, for instance, allows access to multitude of devices, technological capabilities, and interface sizes, and has been shown to support collaboration (Tandler, 2001). Stanford University's Interactive Workspaces project addressed collaboration with this in mind immersing teams with a variety of interactive software and hardware technologies including ceiling-mounted scanners and large computer displays (Johanson, Winograd, and Fox, 2003). This aligns with pervasive technology precepts where tools are embedded within the environment anywhere a user might need them. Using multiple monitor workstations, or 'multimon', resembles this prospect but on a smaller, less wholly public scale. Yet, despite the potential for using multiple monitors, including allowing multiple users to work together and providing more real estate in

which to carry out multiple functions simultaneously, research emphasizes single users working with single workstations. Grudin (2001) submitted influential work on the usage of multiple monitors by a single individual, finding that persons typically partition tasks among the monitors using one for primary work activities and the other for secondary and residual work. However, little research could be found that has explored collaborative dynamics involved when teaming multiple monitors with multiple users (Kies, Williges and Rosson, 1998). Chong, Plummer, Leifer, Klemmer, Eris and Toye (2005) analyzed collaboration among pair programmers, a concept evolving in software development coding where the 'navigator' directs the 'driver' in their manual achievement of a given task. In this sense, the pair assumes asynchronous collaboration in that the navigator tells the driver what to type and the driver fulfills the duty, switching roles whenever it is deemed effective. Though the research analyzing interactions, such as gestures and utterances, within this paradigm is in progress, the authors assert that pair programming enhances the reservoir of knowledge, refines and augments the importance of turn-taking, and establishes order and context to collaboration. However, this methodology creates and depends upon asynchronous collaboration. The current research seeks to explore the innate collaborative response among multiple users when using multimon workstations, evaluating whether pairs and larger groups naturally partition roles and assume the pair programming methodology or use the multiple mice, keyboard and screen simultaneously and equally.

In so doing, interactions, defined by assessing the amount of communication that transpires within a group including verbal utterances and physical gestures as delineated by Hathorn and Ingram (2002), were analyzed within the CL³ and a similar computer lab known as the 'Runway' located within the same Uris Library. (These two computer labs will be referred to as CL^3 and Uris Runway in the following discussions.) Additionally, user preferences among patrons of CL³ were surveyed, and physical ergonomic data, such as anthropometric dimensions and sound levels, were captured. Methodologies and results particular to each focus are provided within three sections:

1. Physical ergonomics of CL³
2. Collaboration analysis in CL³ and Uris Runway
3. Survey results of CL³ patrons

2. Physical Ergonomics of CL^3

The furnishings, technologies, and the ambient environment of the CL3 and how it affected the users and their productivity were analyzed in terms of optimal physical ergonomic standards. Measurements of the workstations and chairs, the force required to move the workstations, sound level, were captured and as well as user preferences and opinions regarding the work space in CL^3.

2.1. Physical Dimensions

In order to analyze the physical design of the furniture and equipment at CL^3 for its ergonomic factors, the dimensions and the range of adjustability of the desk, chair, and the monitors were measured (Figure 2.1.1. and Figure 2.1.2.). Comparing the measurements to the guidelines for a standard computer work area, it was determined that all the dimensions, including the desk height, chair height, leg room, work area top, and the level of the top of monitor casing for eye level, meet the requirements. This indicates that the workstation was successfully designed to fit ergonomically to users of all sizes.

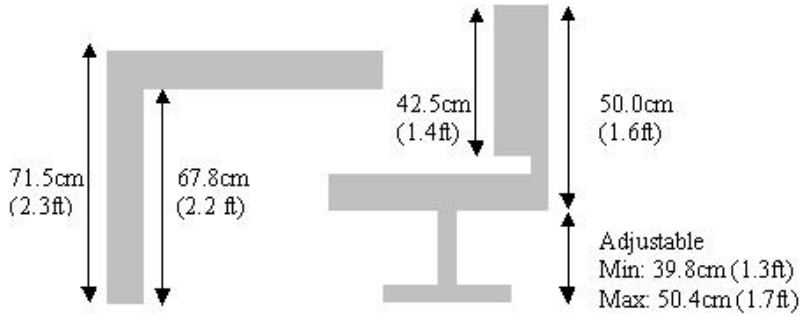

Figure 2.1.1 Dimensions of the workstation and chair.

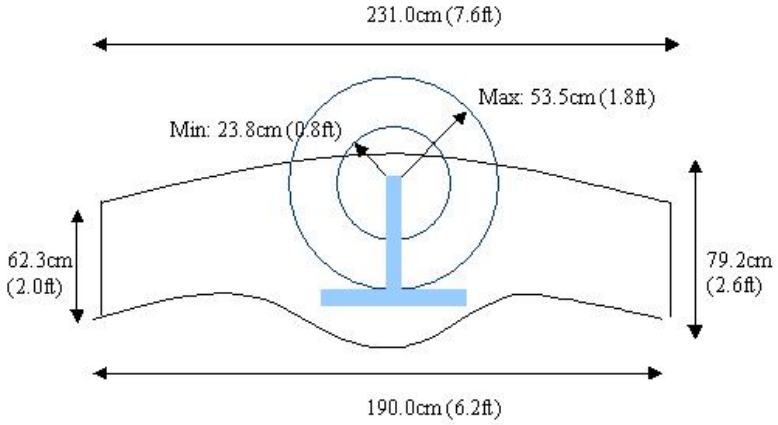

Figure 2.1.2 Dimensions of the workstation top and the range of monitor adjustability.

Using the program “Mannequin Pro”, the optimum view for the 95% male and 5% female in relation to the seating location and the monitor position is illustrated below in this section. However, in this study, due to the limitations and technical difficulties of the program, the following assumptions were made in order to create the case models:

1) The overall shape of the workstations was illustrated to be rectangular, not taking account of the curvatures of the desk.
2) The users were seated perpendicular to the horizontal axis of the workstation.
3) The two monitors are aligned adjacent to each other.

Three possible seating positions and the change in the optimum view of the users are illustrated in this section. The first position is a person sitting at the center of the desk facing forwards and looking at both screens. In order to get the optimum view of the screens, the diagram below (Figure 2.1.3.) illustrates the necessity in adjusting the monitor positions depending on the size of the individuals. The heights of the monitors are set to fit the optimum view of a 95% male in all the diagrams. It is evident that different monitor height adjustments must be made in order for the screens to fit into the optimum view of the two different types of users. The workstations at CL3 do have the flexibility to adjust for the comfort of users of all different sizes; however, it would be more of a personal responsibility and choice to make these adjustments.

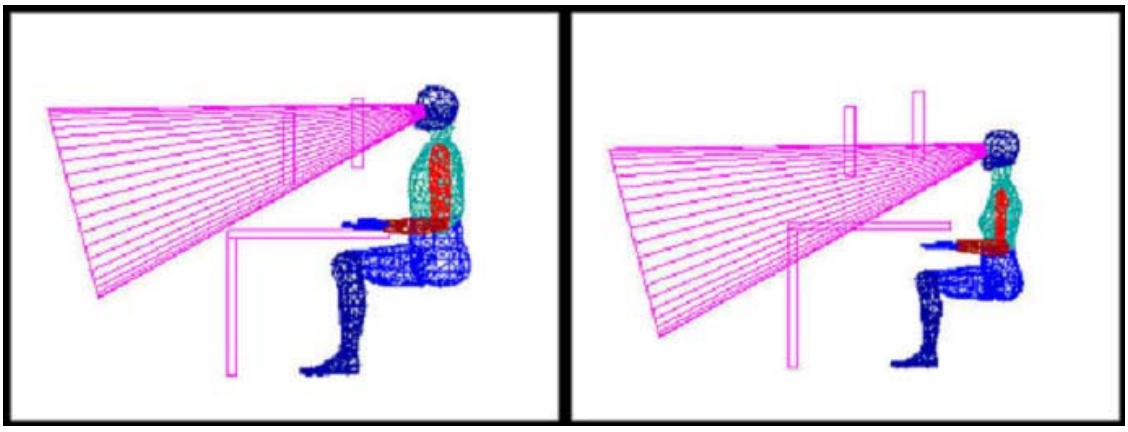

Figure 2.1.3. 95% male (left) and 5% female (right) seated at the center facing forward at both of the screens. The two monitors indicate the positions of the maximum and minimum distance from the user.

The second possible arrangement is when a person is sitting to one side of the desk, where the chairs are originally set for seating, and looking forwards so that he/she is offset from the screens. From the top and the front view, it is visible that the monitors positioned at the center barely

enter the optimum view of both types of the users (Figure 2.1.4.). This indicates that when seated at one side of the workstation, the user needs to turn either the head or the body at an angle to get an optimum view of the screens. When the user uses the keyboard or the mouse while looking at the screen, the user will tend to turn his/her head to an angle to face the screens, unless the user turns his/her entire body.

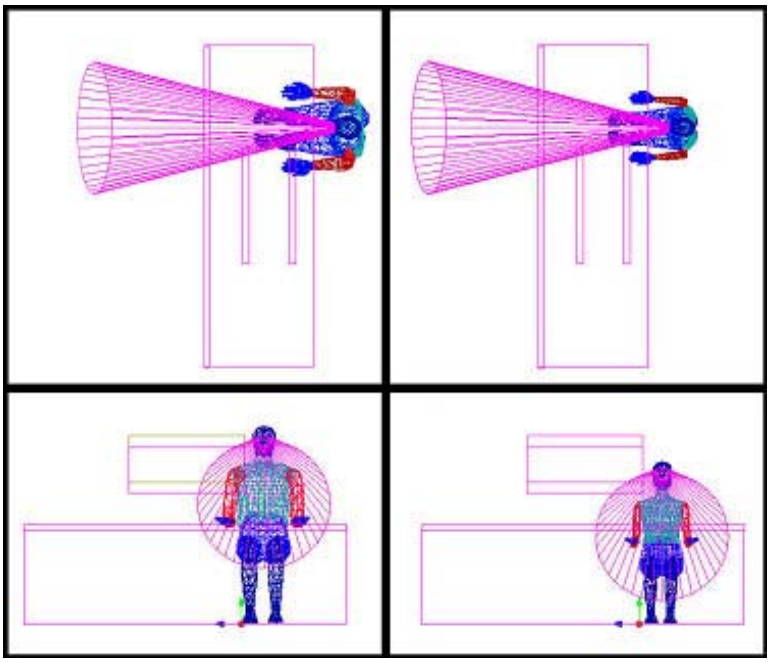

Figure 2.1.4. Top and front view of 95% male (left column) and 5% female (right column) seated at one side of the workstation facing forward. The two monitors indicate the positions of the maximum and minimum distance from the user.

The third arrangement is when the user is sitting to one side of the workstation and rotates his/her head at an angle to look directly at the screens (Figure 2.1.5.). By turning the head to about 45 degrees, the monitors set to the farthest distance from the user will then enter the optimum view of the user.

Another interesting observation is that when the user is seated at the side of the workstation, even with the monitors angled at 45 degrees the screens do not come into the optimum view. The screens will only enter the user's optimum view when the user actually turns his/her head towards the screens (Figure 2.1.6.). From these studies, it is evident that when positioned at the side of the workstation, which is where the chairs are originally positioned and the most common sitting position when more than one person uses a station for collaborative work, the user needs

to turn their head at an angle in order to get the optimum view of the screens. Working in this position for long periods of time will increase the chance of neck injury.

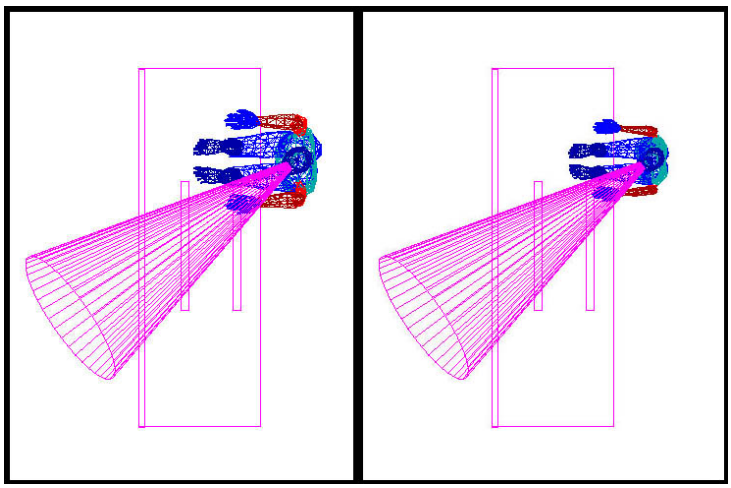

Figure 2.1.5. 95% male (left) and 5% female (right) seated at one side of the workstation looking at the screens at an angle. The two monitors indicate the positions of the maximum and minimum distance from the user.

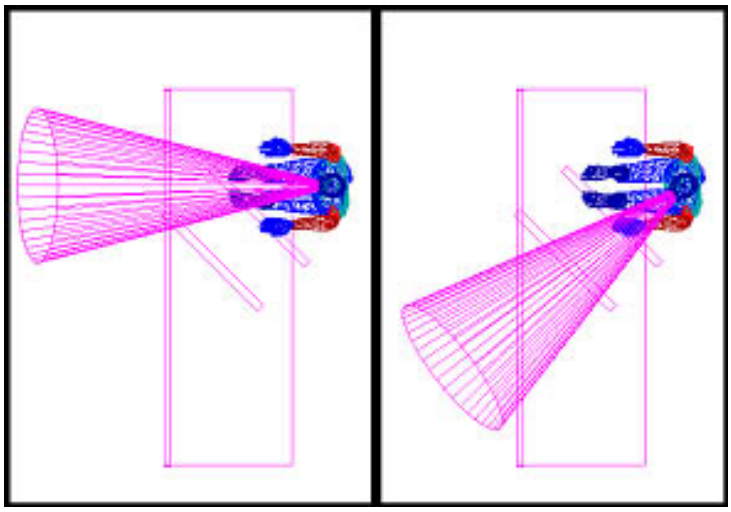

Figure 2.1.6. 95% male seated at one side of the workstation with the screens turned at an angle, looking forward (left) and toward the screens (right).

Additionally, regarding the survey question, "How often do you adjust the following furniture?" the following data was collected (Figure 2.1.7.). For chair height, screen viewing distance, and screen angle, the greatest percentage of CL3 users, about 40% on average, indicated that he/she only adjusted them some of the time that he/she goes to the lab. In contrary, only 19%, 14%, and 15% of the users indicated that he/she always adjusted the chair height, screen viewing distance, and screen angle, respectively. This indicates that the majority of the users are working in CL3 in a posture that could increase the chance of injury for the majority of the time.

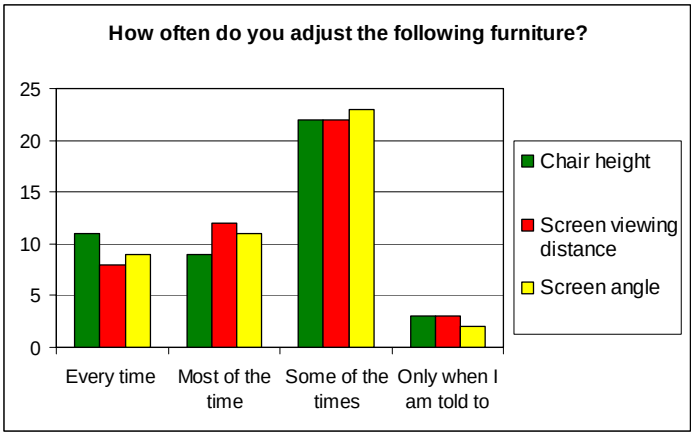

Figure 2.1.7. Survey data distribution of the frequency of the users adjusting the chair height, screen viewing distance, and screen angle.

In addition, the shape of the CL3 desks may not be conducive to collaborative work. The inside curve of the desks (Figure 2.1.8.) limit the space in which the users can sit and gather around the computer, as well as the ability to see one another face-to-face.

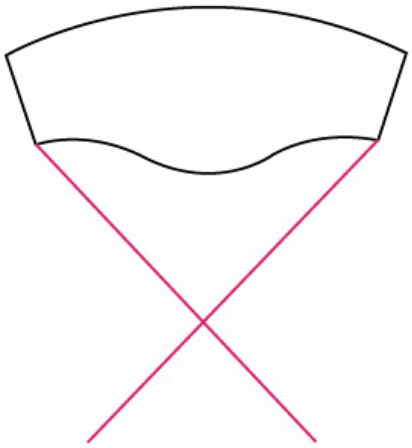

Figure 2.1.8. CL3 desks: Sitting space closes in

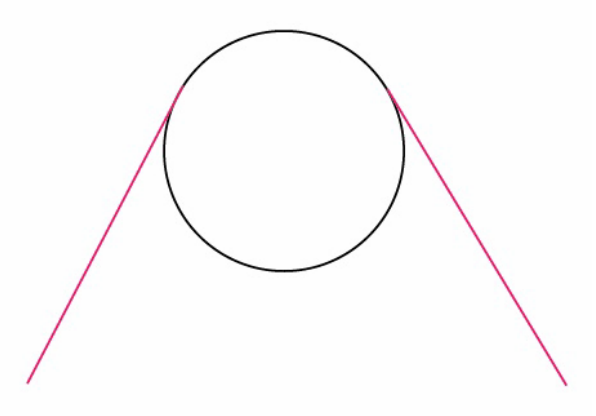

Figure 2.1.9. Uris Runway desks: Sitting space open

The curved or even straight edge of the tables in Uris Runway (Figure 2.1.9.) allows people more space to gather around the screens and to interact with one another. If space was not a concern, it may offer more space and interaction potential had if CL³ desks were convex so that the users can sit on the curved edges, placing the screen on the opposing and smaller convex bump of the table.

2.2. Force Analysis for Moving Workstations

Whether people perceive the work stations as heavy or light and whether the judgment matches with the actual force requirement used for moving them around was analyzed in order to have a better understanding for possible collaboration. Using a force gauge, the force required for pushing the work desks for a very short distance (1 foot) was measured. Locations of force measurements are shown in Figure 2.2.1.. Table 2.2.1. shows how much force is required for each position marked on the desk. Three readings were obtained (using kilograms) from each position and were averaged to create one force requirement; the maximum force required is also indicated.

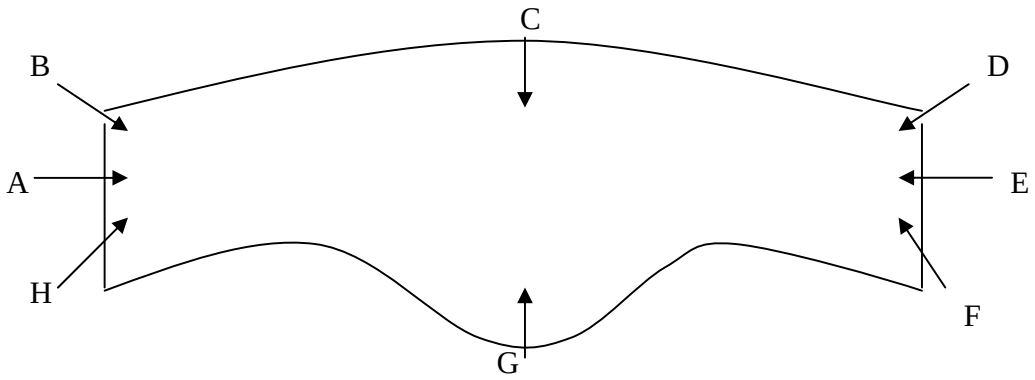

Figure 2.2.1. Location of force measurements

Table 2.2.1. Force Measurements

Position	Reading 1 (kg)	Reading 2 (kg)	Reading 3 (kg)	Maximum (kg)	Average (kg)
A	17.1	16.9	16.0	17.1	16.7
B	16.5	12.1	11.8	16.5	13.5
C	17.5	15.8	16.8	17.5	16.7
D	17.0	15.5	16.0	17.0	16.2
E	16.2	16.9	16.0	16.9	16.4
F	15.1	13.3	11.2	15.1	13.2
G	18.6	13.8	11.6	18.6	14.7
H	11.1	11.8	12.6	12.6	11.8
					14.9

Forces required to move the work stations around in CL³ were compared with the standard force requirements using the Liberty Mutual Manual Materials Handling Guidelines of Population Percentages for Pushing Tasks (used to be called and known as the Snook table), which analyzes whether the force with certain hand height for a time period would cause potential injury. For

copyright reasons, an actual table of pushing tasks initial force can be viewed at the following site: (under Table 7 & continued)
http://libertymmhtables.libertymutual.com/CM_LMTablesWeb/pdf/LibertyMutualTables.pdf

The population percentages in the tables are based on weights selected by subjects in the laboratory working as hard as they could without straining themselves, or without becoming unusually tired, weakened, overheated or out of breath. Jobs designed ergonomically should fit most workers and that is why 75% of the female work population is selected as a design starting point. The tables are for manual handling jobs with physical requirements such that as many workers as possible can perform them without risk of injury. After comparing the force required to move work stations CL^3 with the Liberty Mutual Table, it was found that the force range of 11.8 kg to 16.7kg was within greater than 90th population percentile, meaning that most people could perform this task without the risk of injury. Moving the desks around, however, also means that one must factor in the position of pushing, and not all postures are acceptable even if the force required were within the safe range.

2.3. Sound Level Analysis

For the sound level analysis, a sound meter was used to take the maximum sound level within CL^3 and Uris Runway. Measurements were taken for 10 to 15 minutes in each room, and only the highest value was recorded. Results are shown in Table 2.3.1. and Table 2.3.2..

Table 2.3.1. CL^3 Sound Levels

Observation Date	Max Sound Level (dB)	# of Users
March 14, 2006 4:55PM	61.1	6
April 5, 2006 12:55PM – CIS 300	80.5	18 students, 1 teacher
April 11, 2006 2:15PM	65.2	

Table 2.3.2. Uris Runway Sound Levels

Observation Date	Max Sound Level (dB)	# of Users
April 6, 2006 2:15PM	68.6	18
April 11, 2006 2:20PM	69.2	15
April 17, 2006 6:30PM	81.2	

Unless there is a class, CL^3 is relatively quiet (this is evident from other observations). On average, the sound levels in Uris Runway are louder than the CL^3 sound levels. More talking and interaction can be seen in Uris Runway at all times. Factors that may be attributed to the difference in interaction levels between the two computer lounges are:

- The more open and bright atmosphere of Uris Runway
- The ability for people to walk through the space to get to/from the Cocktail Lounge
- The shape of the computer desks

These characteristics of Uris Runway contribute to the "social" atmosphere, allowing the users to feel free to speak to each other loudly, helping collaboration. CL^3, with its closed doors, earthy tones and high-tech machinery, adds to the laboratory-like atmosphere in which people do not feel as welcome to talk out loud.

Sound Levels and Human Response		
Common sounds	**Noise Level [dB]**	**Effect**
Rocket launching pad (no ear protection)	180	Irreversible hearing loss
Carrier deck jet operation Air raid siren	140	Painfully loud
Thunderclap	130	
Jet takeoff (200 ft) Auto horn (3 ft)	120	Maximum vocal effort
Pile driver Rock concert	110	Extremely loud
Garbage truck Firecrackers	100	Very loud
Heavy truck (50 ft) City traffic	90	Very annoying Hearing damage (8 Hrs)
Alarm clock (2 ft) Hair dryer	80	Annoying
Noisy restaurant Freeway traffic Business office	70	Telephone use difficult
Air conditioning unit Conversational speech	60	Intrusive
Light auto traffic (100 ft)	50	Quiet
Living room Bedroom Quiet office	40	
Library Soft whisper (15 ft)	30	Very quiet
Broadcasting studio	20	
	10	Just audible
	0	Hearing begins

Figure 2.3.1. Description of Sound Levels (courtesy of http://www.eie.fceia.unr.edu.ar/~acustica/comite/soundlev.htm**)**

From Figure 2.3.1., one can see that the average noise level in CL³ with no class is in the "intrusive" level while the normal noise level in Uris Runway is "telephone use difficult." The noise level in CL³ during class and Uris Runway after dinner time reaches "annoying" levels. However, there is no danger of hearing damage from the noise levels in either of the spaces.

2.4. Rapid Upper Limb Assessment (RULA)

Postures were measured using the Rapid Upper Limb Assessment method, also known as RULA, to determine whether there was an increased risk for injury in CL[3]. RULA is a postural targeting method for estimating the risks of work-related upper limb disorders. A RULA assessment gives a quick and systematic assessment of the postural risks to a worker. The analysis can be conducted before and after an intervention to demonstrate that the intervention has worked to lower the risk of injury. In so doing, using photo-documentation, individuals' postures were analyzed while working in the CL³. When using RULA method, arm, wrist, neck, trunk, leg, muscle use and force load are taken into account. There are four different action levels according to the scores obtained and these are used as references for further investigation of either the body posture or the equipment itself. Here are a few representative examples:

Figure 2.4.1 RULA score: 2 (Acceptable)

Figure 2.4.2. RULA score: 2 (Acceptable)

Figure 2.4.1. and Figure 2.4.2. illustrate an action level 1, with a score of 2, meaning that the person is working in the best posture with no risk of injury from their work posture. Three out of fourteen subjects had a score of 2.

Figure 2.4.3. RULA score: 3 & 4 (Investigate further)

Figure 2.4.4. RULA score: 3 & 4 (Investigate further)

Figure 2.4.5. RULA score: 3 (Investigate further)

Figure 2.4.3 – 2.4.5. illustrate an action level 2, with a score of 3 or 4, meaning that the person is working in a posture that could present some risk of injury from their work posture, and the score most likely is the result of one part of the body being in a deviated and awkward position, so this posture or equipment should be investigated and corrected. Eight out of fourteen subjects had a score of 3 and four out of fourteen subjects had a score of 4.

Figure 2.4.6. RULA score: 6

Figure 2.4.6 illustrates an action level 3, with a score of 6, meaning that the person is working in a poor posture with a risk of injury from their work posture, and the reasons for this need to be investigated and changed in the near future to prevent injury. Only one out of the fourteen subjects had a score of 6.

Most of the subjects being investigated had a common score of either 3 or 4, and this could be representative of the population using the CL³ lab. This indicates that perhaps certain adjustment

could be made to the desk, chair or computer to contour and support the body in order to minimize potential risk posed by sustaining awkward postures of a long period of time. Perhaps education on correct body posture could also be looked at in order to prevent injury.

2.5. Survey Results for Issues Concerning Physical Ergonomics

In addition to objective measurement of physical ergonomics of CL^3 lab, we also employed a survey to complement the objective data and tried to explore user opinion categories. The survey was conducted concerning not only physical ergonomics of CL^3 but also collaborative behaviors and user preference of CL^3 patrons. Fifty-five responses were received. Details of the survey will be discussed in section 4. Here we will discuss some questions in the survey concerning physical ergonomic issues.

Concerning the question "How would you rate the importance of the following items for collaborative work in any computer facility?" The result is presented in Figure 2.4.7.. It is evident that users are more concerned with the noise that they make as they work more than the sounds that others are making. Therefore it is crucial that CL^3 makes it comfortable for its users to speak and make noise as they work. The lab should make it more apparent that the users are allowed to make sounds.

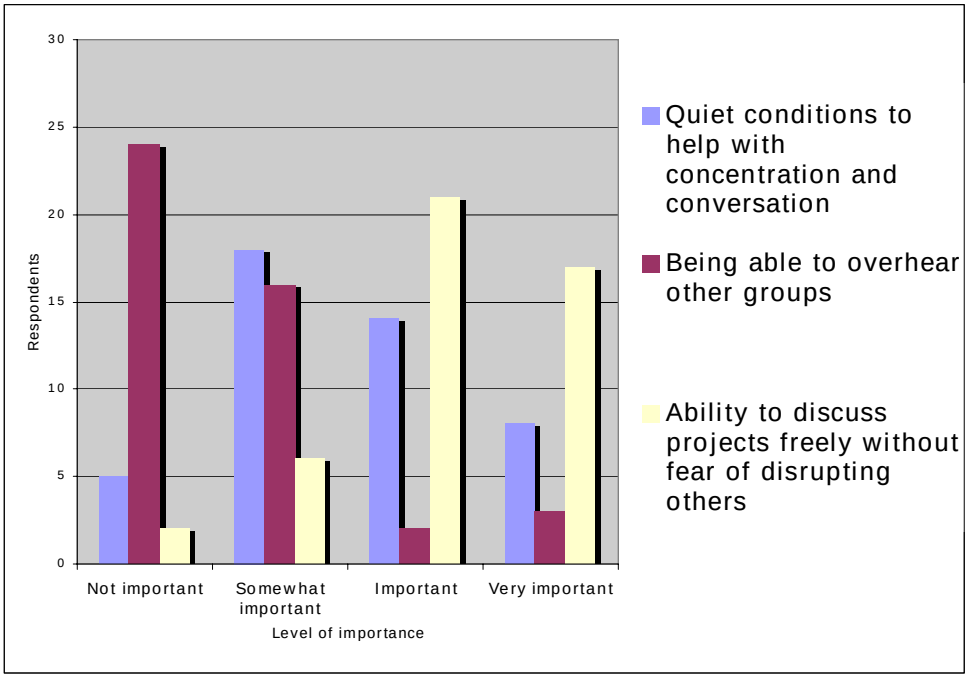

Figure 2.4.7. Result for Question 9: "How would you rate the importance of the following items for collaborative work in any computer facility?"

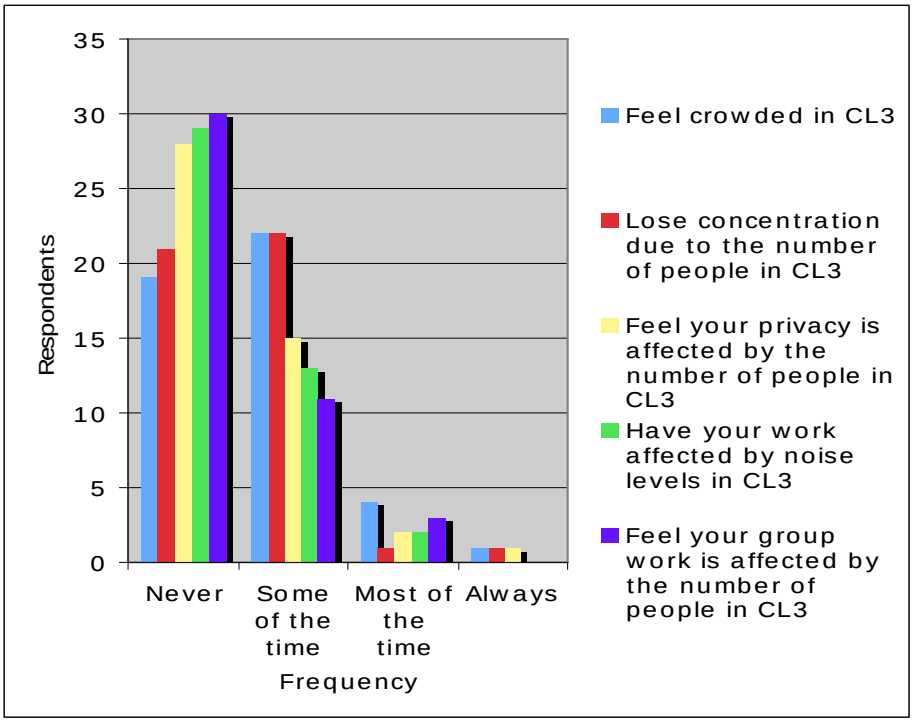

Figure 2.4.8. Results for Question 18

Additionally, most of the people did not find privacy or number of people in the lab to be of any concern. This is represented in Figure 2.4.8.. Some students even suggested that they make the lab bigger to allow space for more computers and users.

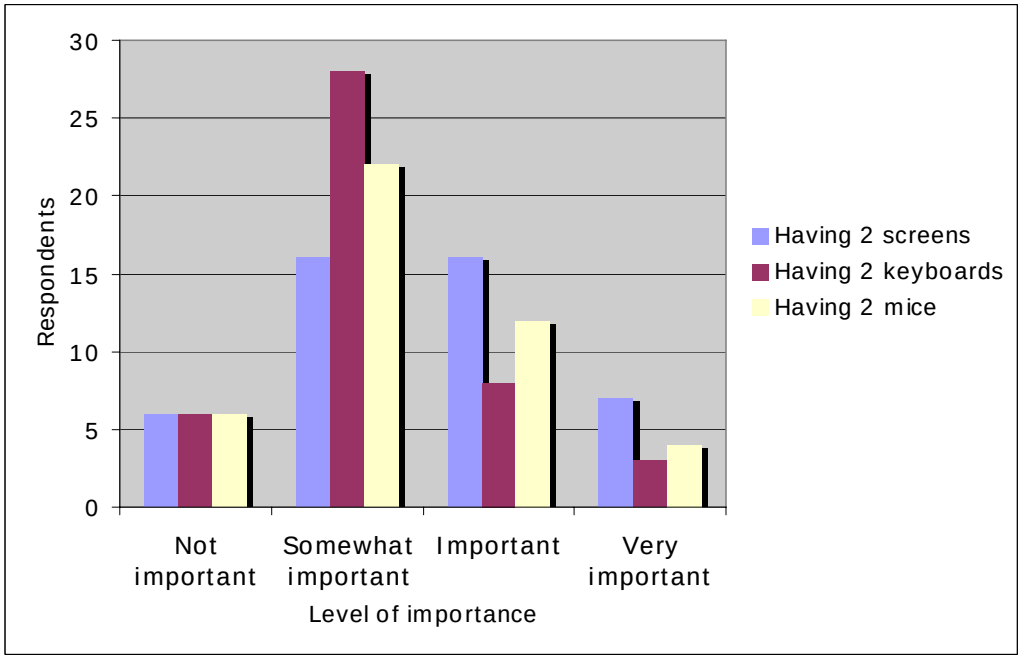

Figure 2.4.9 Result for Question 9: "How would you rate the importance of the following items for collaborative work in any computer facility?"

Concerning the question "How would you rate the importance of the following items for collaborative work in any computer facility?", the results show that the users do not have strong feelings for the dual technologies offered in CL3. However, other results show that some people find it useful, and one of the attractive features that should be kept in the lab.

According to survey results of patrons using CL³, most people did not know the work stations were movable or did not know it was allowed to be moved around.

When asked about the following:

1) **Ability to customize work area by moving chairs, tables, and computers**

Not So Important	Somewhat Important	Important	Very Important	N/A
12%	28%	21%	18%	21%

Most of the people do not see customizing the work station as both of the extremes but instead they only feel like it was somewhat important, meaning that perhaps they are happy with the initial equipment and layout provided by the lab.

2) **How often do you rearrange the computer tables in CL3?**

	Every time	Most of the time	Some of the time	When I'm told	Never moved	N/A
Frequency	3.5%	5%	28%	10.5%	35%	18%

To see how important collaboration takes place when people are moving the tables around, we asked people reasons that they moved the work stations around.

3) **Reasons to move table**

- 31.5% Create better working station
- 28% To improve collaboration
- 33% Never moved tables

Although a substantial number of people moved the workstations around from time to time, 35% said that they have never moved the work stations around. The following questions were also included in the survey:

4) **If you have never rearranged the tables in CL3 before, why not?**

- 37% I didn’t need to
- 22% Didn’t know it was allowed
- 15% Didn’t know it was movable

Most of the population said that they did not need to, while the same number of people said that they did not know the desks were movable or that the tables were allowed to be moved around. In other survey questions, it is evident that that cables and wires attached to the tables and connected to the floors was one big reason that stopped people from moving the workstations. They suggested that it would have helped if they were given signs, guidelines or instructions as to how to correctly move the workstations around without causing any potential damage to the workstations. Also, surveyed subjects indicated that if the tables were lighter, they would definitely move them around for better collaboration. Therefore, although the force required to move the tables around were within the safe range and most representative population percentile, it would have helped users to figure out that the tables were movable if they were actually instructed or if the tables could be perceived as easy to move. A suggestion would be to add hand grips to the table edge, or bigger wheels to the tables, both are indications showing that the tables could be moved.

3. Collaboration Analysis of CL^3 and Uris Runway

3.1. Methodology

Direct observations were used to gain insight about the functionality of the space and hardware as it relates to collaboration, the frequency of use of the hardware, the interaction between group members using a workstation while survey questions were used to assess user opinions regarding collaboration. The Runway was used as a source for comparison among collaborative aspects of CL^3. Analyzing frequency of how students interacted in a group was used to capture level of collaboration. Specifically, the observations would look at several key actions which represented collaboration taking place. The events included a person talking, using the mouse, keying, pointing at the computer screen, and pointing at other objects such as papers or notebooks. While these were the most observable actions, talking was decidedly the most indicative action of collaboration. After several trials of looking at students collaborate in the CL^3 laboratory, a formal observation method was developed.

The final observation sheet for CL^3, shown in Figure 3.1.1., contains a picture of the workstation to mark where the group members were seated in order to make the observations more comparable between various groups. The final sheet also has spaces to mark the arrangement of the room in CL^3 to see if there is much deviation in how the workstations are arranged; a small chart was included to list which keyboard and mouse each group member was using. Finally, the chart contained a time based chart for each member of a group. The chart was divided into 40 columns with each column representing 15 seconds totaling a 10 minute observation time for each group. A member would be given a mark for talking, pointing, keying, or mousing if they performed any of those actions in the 15-second time period. While this method does not record exact time and frequency for talking or performing any other action, which would be ideal, it does show a time based method of how and when group members performed an action. In addition, due to the complexity of conversation while collaborating, it was observed that most conversations consisted of single words or phrases which would be exchanged in rapid succession. This method captures this rapid conversation simply by marking the group members who did talk.

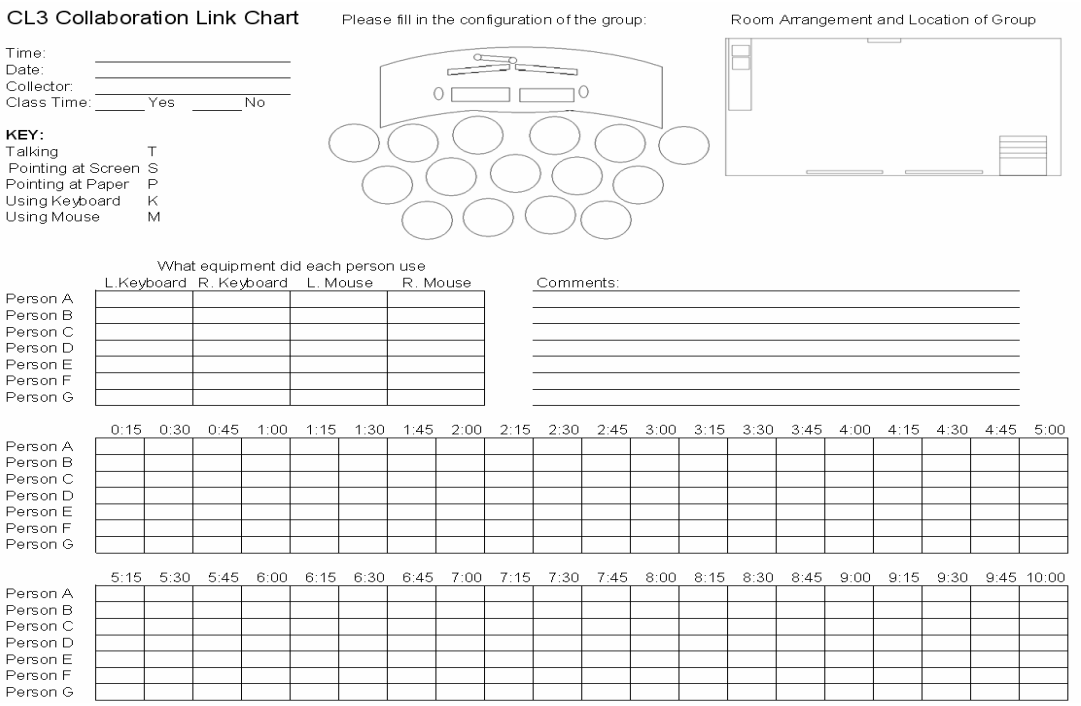

Figure 3.1.1 Final CL^3 Collaboration Observation Chart

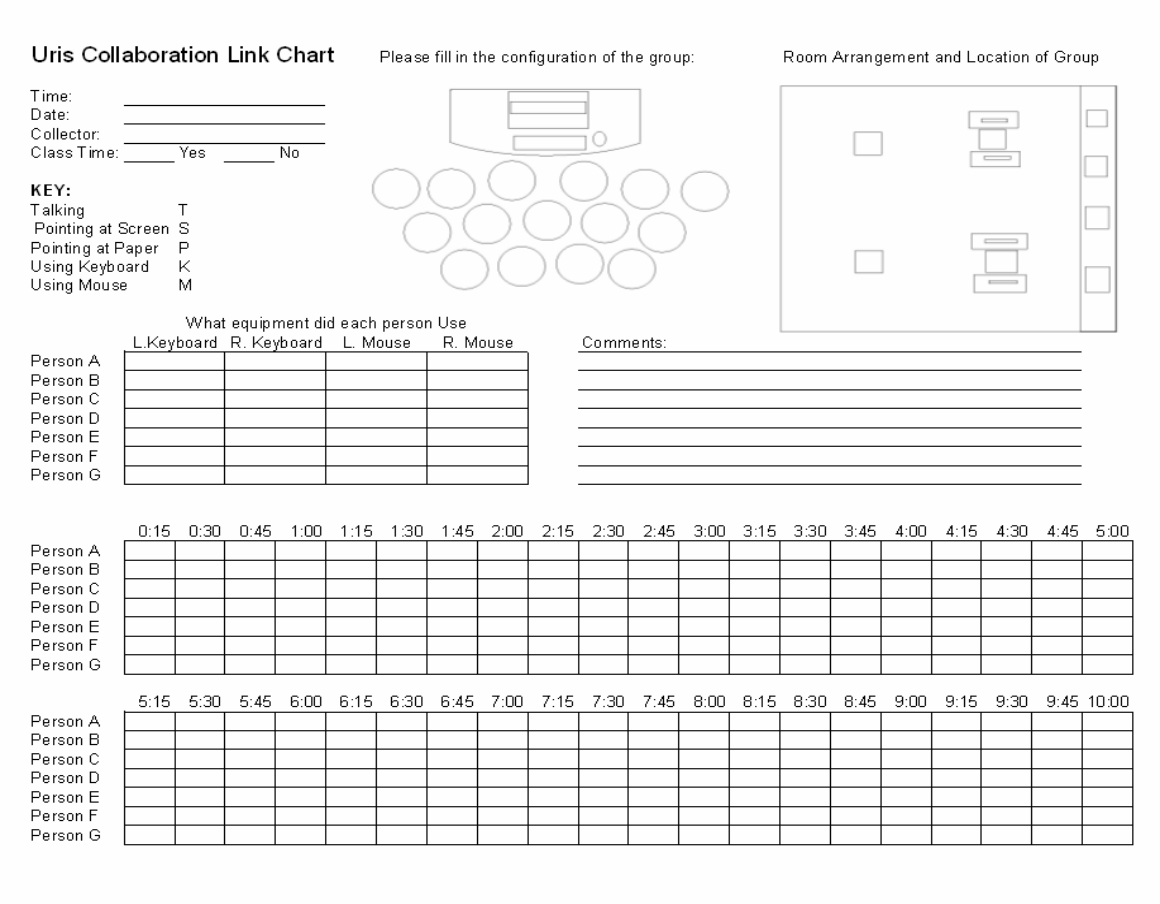

Figure 3.1.2 Final Uris Runway Collaboration Chart

Having developed an observational method for the CL^3 work area, an almost identical sheet was used for observing students in Uris Runway computer area for comparison purposes. The only changes made were that the room arrangement area was changed to reflect the layout of Uris Runway and also the workstation drawing was changed to depict only one computer monitor, keyboard, and mouse. Figure 3.1.2. shows the final Uris Runway Collaboration Observation Chart.

3.2. Observation results and discussion

Nine groups with 2 or more people working as a group in CL^3 and 10 groups in Uris Runway were observed within a two week period. Observations in CL^3 were all made during public time rather than class time. The number of talking, pointing at screens and papers were counted as interactions with people. These numbers were added up for each person in groups into a number of interactions. Coefficient of deviation for the number of interactions within the group was calculated as s.d./mean × 100%. For CL^3 lab, coefficients of deviation of the number of interactions ranged from 2.63% to 14.90%. And the numbers ranged from 0% to 12.50% in Uris Runway. Mean coefficients of deviation were 8.56% and 5.97% for CL^3 lab and Uris Runway, respectively. Since we are looking for collaborative working behavior, the more spread the interaction is within the group, the more collaborative the group should be. So a smaller number of coefficient of deviation suggests a better collaborative group. We can see that difference between the two mean coefficients of deviation in two labs is 1.59%, which accounts for about 11% of the highest coefficient of deviation of a group, this suggests that groups in Uris Runway were a little bit more collaborative than groups in CL^3 lab, in terms of the spread of talking, pointing at screens and paper within the group. We also calculated the average number of interaction for each group observed in CL^3 lab and Uris Runway. The numbers ranged from 1.9 interactions per minute to 8.86 per minute and 1.6 interactions per minute to 9.7 per minute, in CL^3 lab and Uris Runway respectively. Mean average number of interaction per minute was 5.8 for CL^3 lab and 5.85 for Uris Runway. These numbers were very close, which suggests that in terms of the number of interactions for a group, CL^3 lab and Uris Runway are quite similar.

For keying and using the mouse behavior, we calculated the total number of these two and came up with a number of interactions with technology for each person. Percentages within the group were calculated and the ranges were 0% to 100% for both CL^3 lab and Uris Runway. Differences of percentage between the highest percentage and lowest percentage within a group ranged from

27.59% to 100% for CL^3 and 9.52% to 100% for Uris Runway. About half of the groups we observed had a person using keyboard and mouse for 100%. This was true for both CL^3 (44.4%, 4 out of 9) and Uris Runway (55.6%, 5 out of 9). Even if there were more than one people used keyboard and mouse within the group, the differences of percentage were still very large. There was only one group which had a difference of percentage smaller than 50% in both CL^3 and Uris Runway. Also, there are only 2 groups in CL^3 used both sets of keyboard and mouse out of 7 groups that we had data for the use of different sets of keyboard and mouse. This finding suggests that there usually is a dominant user of technology within the group, regardless of whether they are given two sets of keyboards and mice. Interestingly, we observed one group in Uris Runway, of which all 4 group members used either the keyboard or mouse, even they had only one set of keyboard and mouse. Regarding the dominant use of technology, pilot/copilot behavior was investigated. The concept of pilot/co-pilot is called pair programming and uses the terms navigator and driver (navigator tells the driver what to do and looks for errors, etc). We suspected that the dominant user of technology in our observation was the driver of the pilot/co-pilot concept. If this was the case, strong collaborative behavior would be implied. For the pilot/co-pilot model, a negative correlation between the percentage of talking and the percentage of using technology should be expected. However, as we calculated the correlation between the percentage of talking and percentage of using technology, positive correlation was found in data for CL^3 lab, Uris Runway, and two labs combined ($r = .354, .185, .288$, $p = .070, .398, .043$, respectively). This result suggests that there is little, if any, sign of pilot/co-pilot behavior exist in both CL^3 lab and Uris Runway. People using the technology were actually quite actively involved in the discussion in these two labs, rather than just being told what to do. More specific observation data is listed in Appendix 7.3..

3.3. Survey results for collaboration

As mentioned in Section 2, a survey was conducted concerning physical ergonomics of CL^3, collaborative behaviors in CL^3 and Uris Runway and also the user preference of CL^3 patrons. Questions regarding to collaborative behaviors will be discussed here. Fifty-five people responded to the survey in total with varying levels of response for individual questions on collaboration. These questions related to group size and extent of collaboration in terms of amount of collaborative time in CL^3 and other computer labs. The most frequent group size in CL^3 was three. Approximately 16% of the 44 respondents worked alone and 66% worked in

groups of 2 or 3. Of this group work, 56% of respondents said they spent most of the group time in task related conversations (Figure 3.3.1.). Seven people did not answer this question.

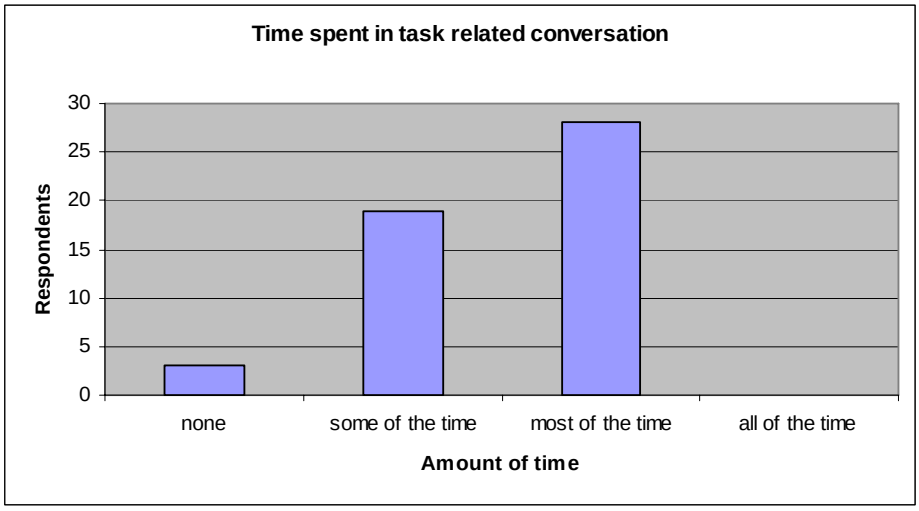

Figure 3.3.1. Time spent in task related conversation

CL^3 was designed to facilitate collaborative classes and, of this class time, 46.5 % said they spend a lot of time (+70% of the time) collaborating while 25.58 % spent a moderate amount of time (30 -70 %) in collaborative work (Figure 3.3.2.). This suggests that CL^3 has been successful in facilitating collaboration within class time. It should be noted that 14 out of 57 respondents did not answer this question.

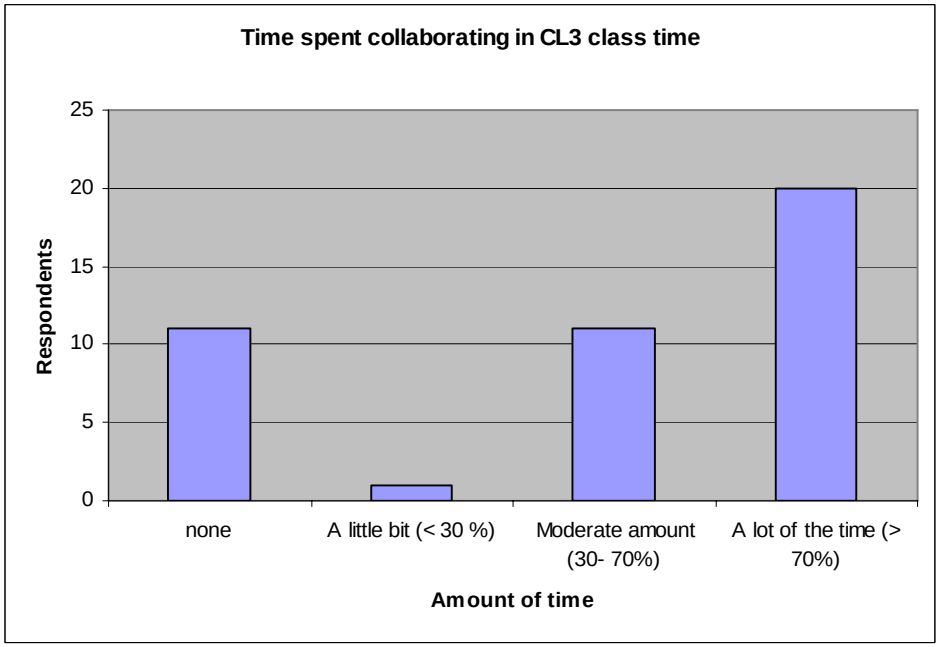

Figure 3.3.2. Time spent collaborating in CL3 class time

During non-class time in other computer labs, only 13% respondents said that they were involved in collaborative work a lot of the time while 69.6% said they collaborated none of the time or a little bit of the time (less than 30% of the time) in other computer labs (Figure 3.3.3.). Eleven out of the 57 respondents did not answer this question.

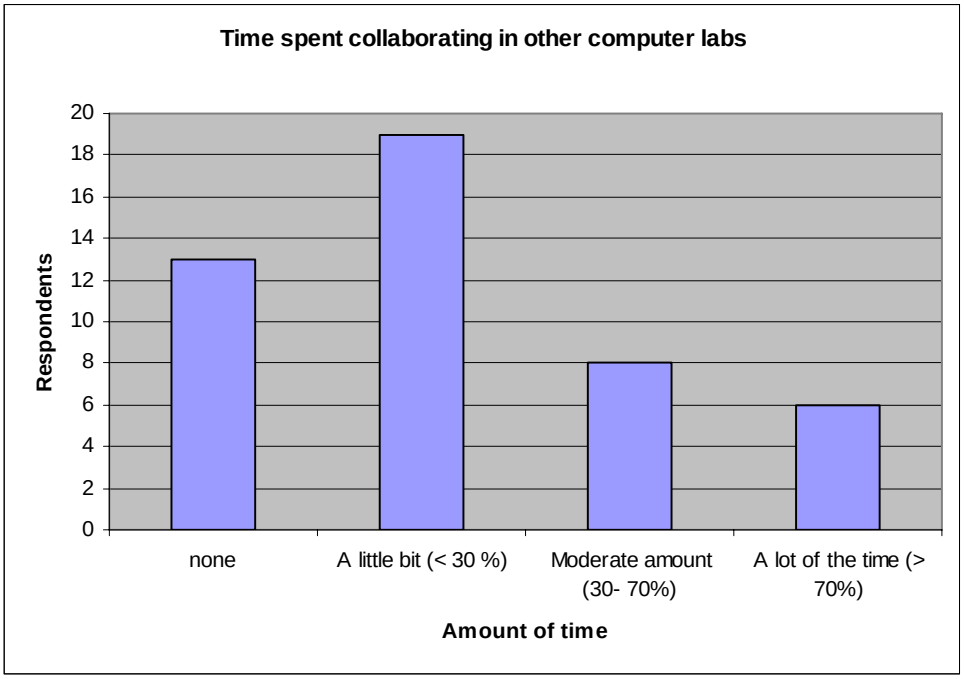

Figure 3.3.3. Time spent collaborating in other computer labs

The survey results suggest that respondents feel CL^3 facilitates collaborative work during class time and a majority of respondents spent most of their time in task related conversation or interaction during group work. CL^3 was designed to increase such interaction. However, even though it was a majority, it was only 56% of the respondents. This suggests that there is still room for improvement in the design of this collaborative space. The survey results may have been compromised to some extent by the number of people who did not answer these particular questions.

4. Summary of Survey Results of CL^3

4.1. Results

User demographics and preferences for the CL^3 were assessed in an effort to establish what aspects of the lab were working well and identify entities within the lab that could be improved. This subjective tool served to complement objective physical and observational data collecting and provide structured data and comparisons between different user opinion categories. The survey was combined with other aspects, collaboration and physical requirements using it to investigate ergonomic issues within the lab as well as collaboration. Overall, the survey was the evaluative method to investigate what the user thought. All three groups worked together in an effort to come up with a set of questions based off literature concerning collaborative computing labs, as well as personal experiences using CL^3. Survey questions were assessed, sieved to 23 questions, and then made available on-line and as the CL^3 desktop homepage through a program called Websurveyor. People participated on a voluntary basis, with no financial or extra credit rewards, and in total 55 people took the time to complete the survey.

The purpose of the first section of the survey was to collect background information about the survey participants in an effort to elucidate who the CL^3 users were. The bar graph below depicts the CL^3 user demographics by stating their class status, major and gender. Fifty-one, or 92%, of the participants were undergraduate students. Out of the other four respondents, two were graduate students and the other two did not fall into either category. Since several computer science courses, such as CIS 300, CS490, CIS490, CS790, CIS 790, INFO490, and CS 100 AEW, are taught in the CL^3 lab, it was important to see how many people utilizing the CL^3 were there for that purpose versus how people from other majors used the CL^3. It was found that 15 of the respondents (27%) were computer science majors, while the other 40 participants (73%) were majoring in other fields ranging from history, to textile design, to chemistry and many others. In addition, since males have traditionally dominated computer science and other engineering related fields, it was important to see what gender most of the CL^3 users were. Although, males accounted for 66% of the participants, the survey did show that a good number of females (34%) were utilizing the CL^3 (Figure 4.1.1.). Among the female users who stated their major, 50% (8) were in the college of engineering while the other half was affiliated with the other colleges at Cornell.

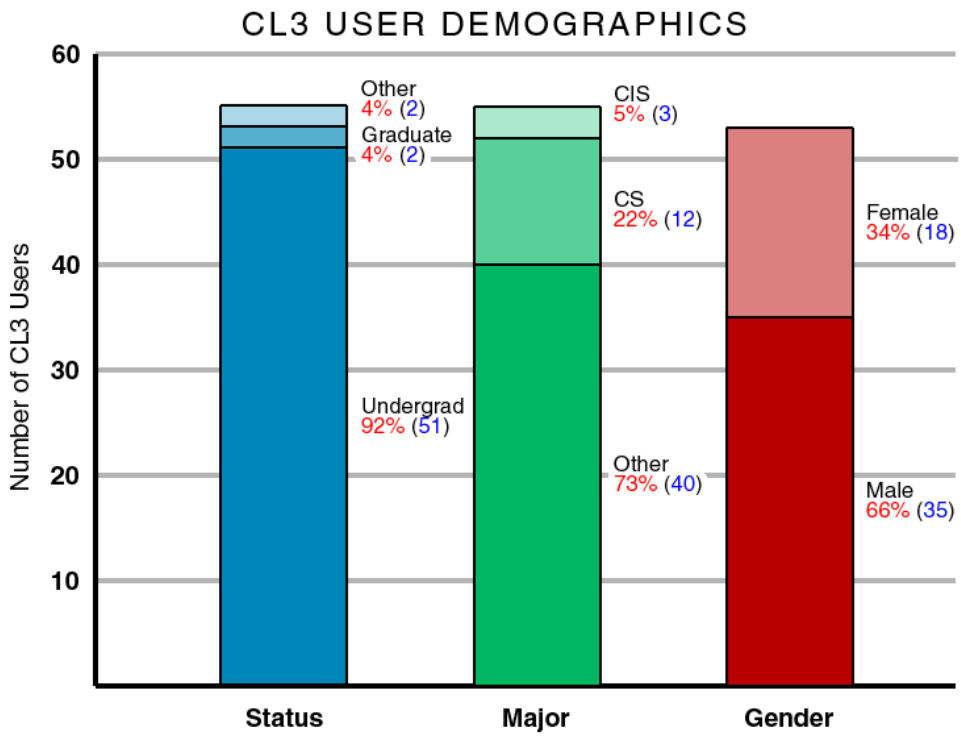

Figure 4.1.1. This chart graphs out the users into status, major, and gender.

The CL^3 lab was designed to be a collaborative computing lab, and, therefore, the survey sought to see people preferred to use the CL^3 rather than other labs on campus particularly for group projects and other collaborative work. The results in Figure 4.1.2. suggest that having to use the CL^3 for class and CL^3's aesthetic qualities were the most common reasons why people use the CL^3. Interestingly, the choice to use CL^3because it is good for group work was only voiced by 19 out of the 55 participants. This may infer that people do not feel the $CL^3$is a good place for collaborative work or it could be that many people may not be aware that the CL^3 lab was designed to be a place that fosters collaborative work. Among the factors that people come to use CL^3, there is correlation of 0.78 between CL^3's location, adequate for holding up meetings, and aesthetically pleasing while there's no strong correlation between other reasons. Although lots of people like CL^3's dual screen/mice feature, people did not come to CL^3 because of that but, instead, came for the atmosphere and space of the CL^3 are.

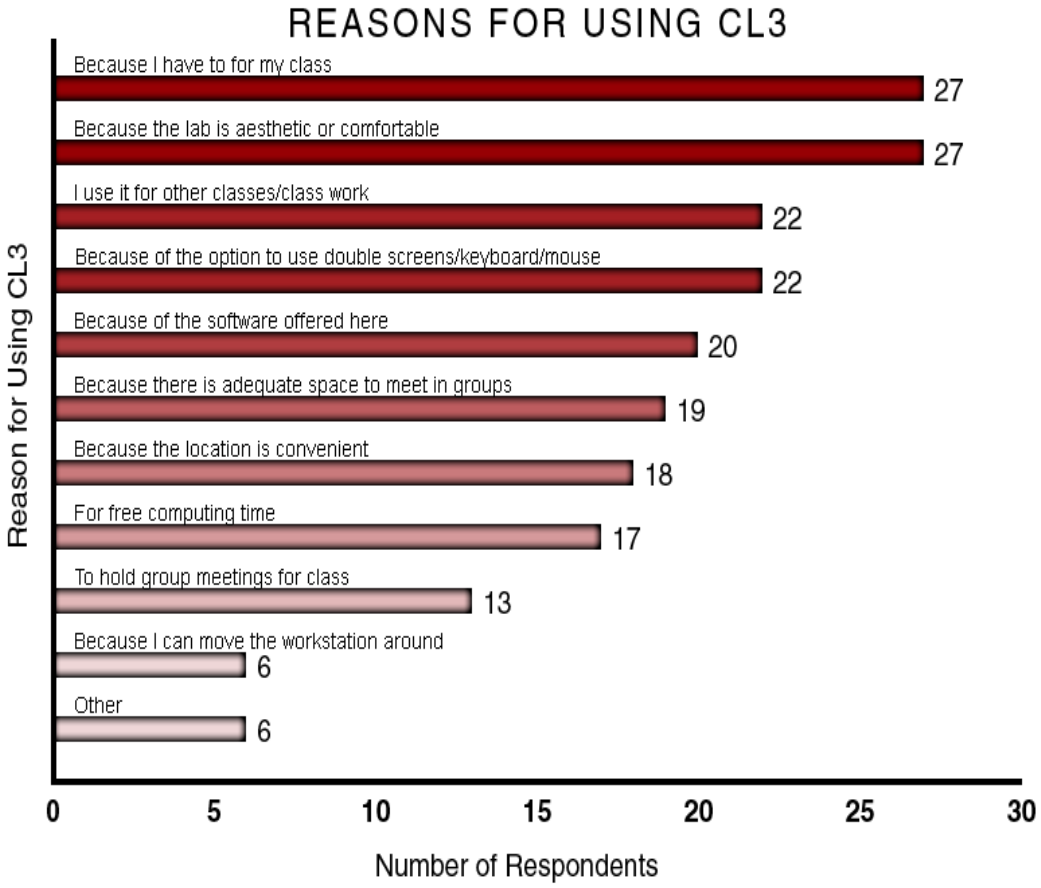

Figure 4.1.2. The top reasons for using the CL^3 lab as described by the users.

Since the three main reasons people were choosing to use to CL^3 were not directly connected to the purposes on which the lab was founded, the next logical step was to see what elements in an environment people felt were important for collaboration. Thus, possible items intended to promote collaboration were listed and were rated as to how important each of the items was by the survey respondent. For each item they were given the choice of listing it as "Not Important," "Somewhat Important," "Important" and "Very Important." Although the descriptive words had no numerical value attached to them, the results still provided a good idea of what elements in an environment people liked and preferred to have when doing collaborative work. In addition, the results from this question showed which entities in the CL^3 lab were being utilized when doing collaborative work and which were not. The data collected from this question is shown in Figure 4.1.3.. We can see that many items rated as important by significant amount of respondents are

actual features in CL[3], such as “ability to work with others on the same computer”, “ability to discuss projects freely without fear of disrupting others”, “having 2 screens”, etc.

How Important Are the Following Items for Collaborative Work?

	Not important	Somewhat important	Important	Very important
Ability to customize work area by moving chairs, tables, and computers	7	16	12	10
Ability to work with others on the same computer	3	11	19	12
Ability to work with others on multiple computers	2	13	20	10
Quiet conditions to help with concentration and conversation	5	18	14	8
Ability to discuss projects freely without fear of disrupting others	2	6	21	17
Having partitions (such as screens or movable walls)	18	14	7	5
Having open space	2	14	19	9
Having dry erase boards	6	12	19	6
Having 2 screens	6	16	16	7
Having 2 keyboards	6	28	8	3
Having 2 mice	6	22	12	4
Being able to overhear other groups	24	16	2	3
Being able to see other groups	24	15	3	3
Being visually removed from other groups	26	12	5	2

Figure 4.1.3. Chart of user’s level of importance in collaboration

Looking at an overall view, factors that would deter someone from using the CL[3] lab were considered, providing a list of reasons to the users as well as the opportunity to freely respond to the questions. Users could choose more than one answer. Figure 4.1.4. shows the responses to the question. The top two reasons that users were deterred from using the lab was the door was locked and the time was posted but no one was there. The area or environment was not necessarily hindering the user from utilizing the lab. These main hindering factors were administrative problems such as lack of staffing and poor signage. However, the main purpose of the study was to determine if the lab is being utilized as a collaborative space.

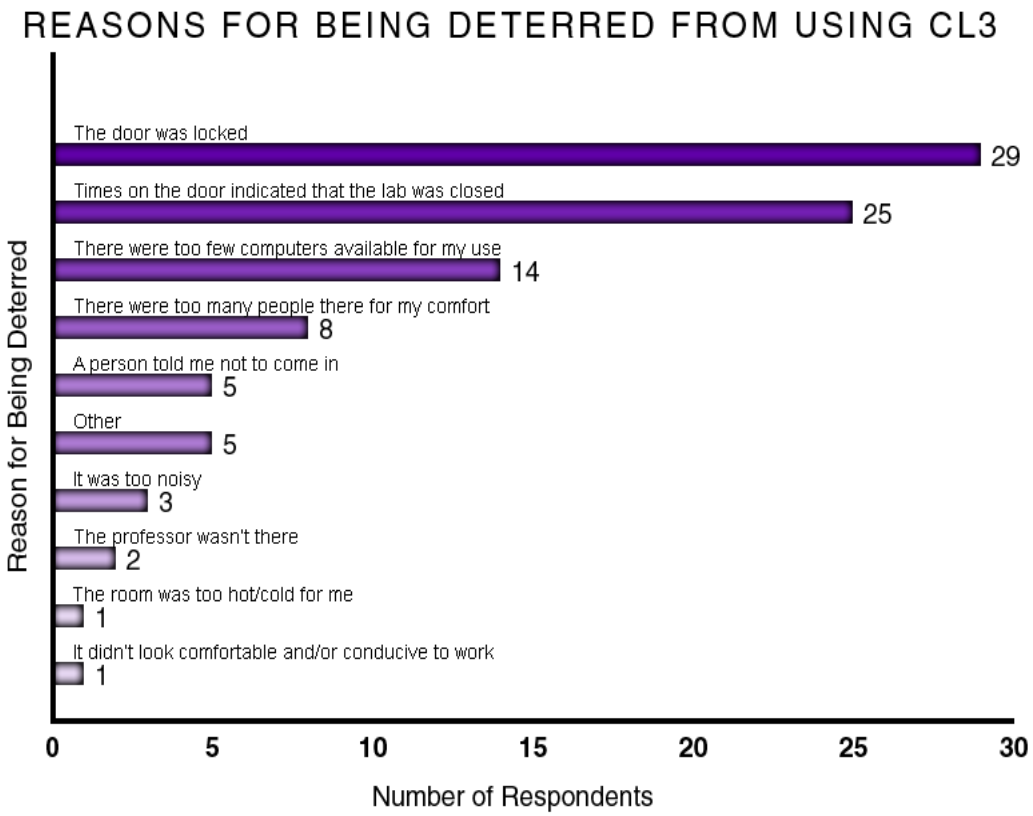

Figure 4.1.4. Reasons for being deterred from using CL^3 lab.

One major feature that the designers incorporated into the space was movable workstations. To incorporate collaborative environment, the workstations were created to facilitate organic movement in the lab. Users would have the freedom to move workstations together to encourage collaborative work. In figure 4.1.5., it was determined the number of movers versus non-movers. Only 43% of the lab users have rearranged the workstations. Among those users, 48% of the users felt that moving workstation helped them create better workspace that can facilitate collaboration. In Figure 4.1.6., the users described how frequently they moved the workstations. Only 10% of those users moved the workstations every time. The majority of people that did move the workstations moved them some of the time. In Figure 4.1.7., the chart breaks down the reasons behind moving and not moving a workstation. While about half of the users are moving the workstations to create a collaborative space, there is still a small population of users who are not aware of the workstations capabilities or in this case, mobility.

Fewer wires, ease of plugging and unplugging, lighter workstations, and signs were among the top reasons that users thought would facilitate moving the workstations in CL^3 more often. However, 13 respondents said that they simply would not move the workstations.

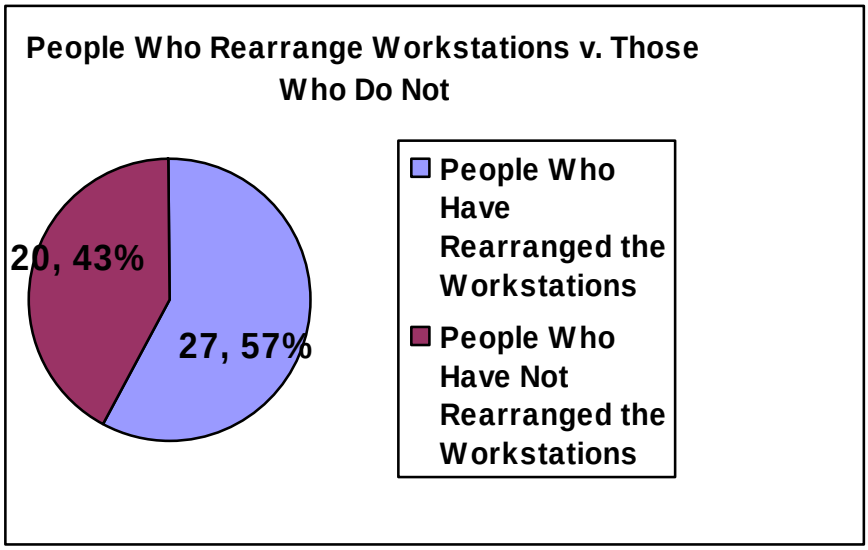

Figure 4.1.5 Chart comparison of movers vs. non-movers

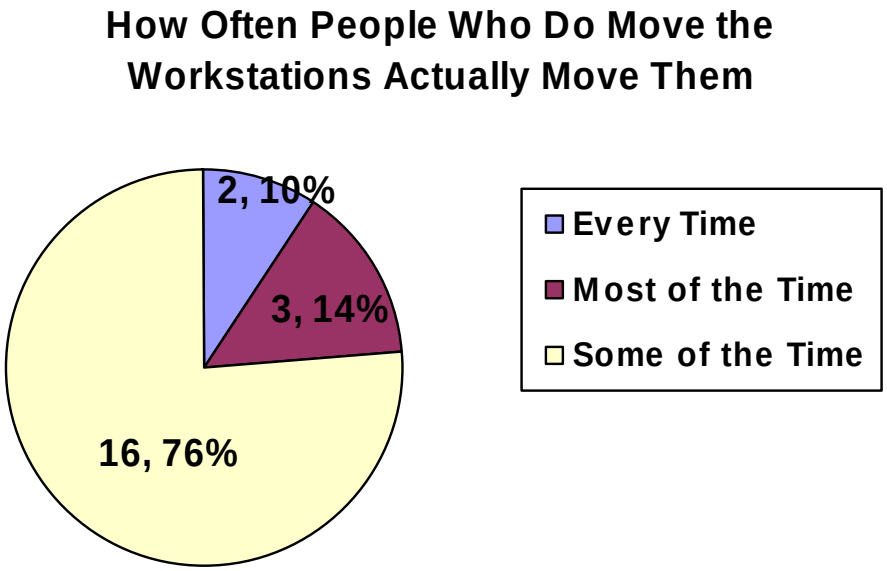

Figure 4.1.6 Chart of frequency of moving the workstations

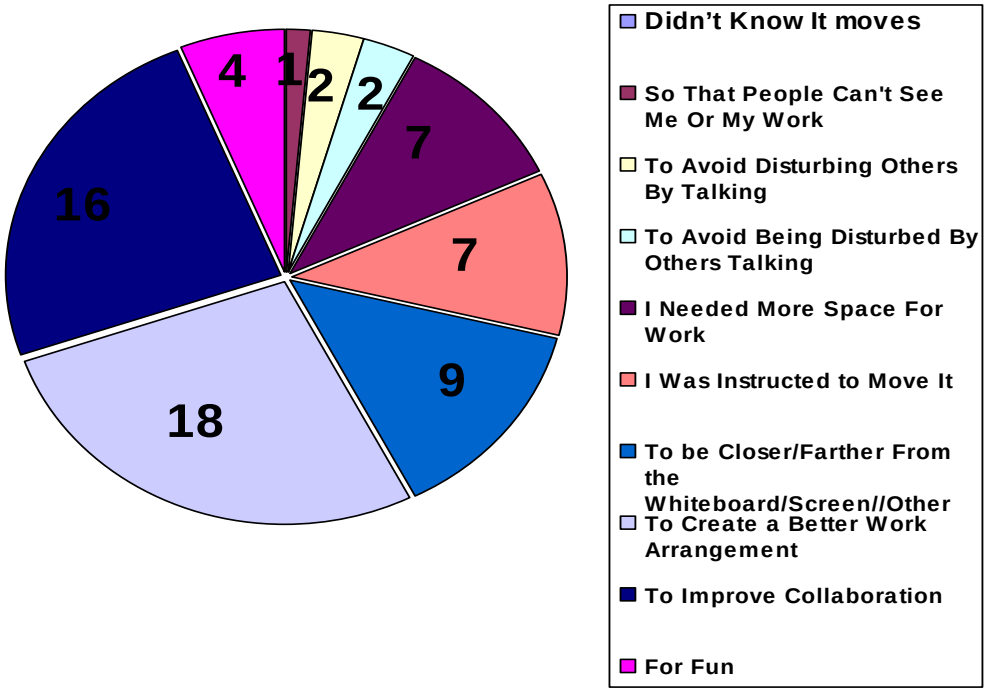

Figure 4.1.7. Chart breaking down the movers and non-movers into various categories.

The survey concluded with a few open-ended questions, designed to provide the users the opportunity to give feedback about the CL^3 lab. With being constrained to a limited number of questions, the open-ended questions of likes and dislikes provided a faster means of determining the effectiveness of the CL^3 design and whether needs are being met by the design of the space. People used the lab for classes, aesthetic appeal, comfort, and the dual equipment such as the dual monitors. With the open-ended questions, the top reasons for using the lab became evident with the repetition of responses. Reasons for liking the CL^3 included: the dual screen option, the mobile furniture, the software and hardware available, fast computers, the ambient environment, ample space, high ceilings, quiet work environment, the whiteboards, the availability of electrical outlets, and the fact that it is a good space for collaboration. Reasons for disliking the space also became evident. The limited hours and lack of signage became echoing themes. Other physical constraints were also mentioned, the shape of the room and table space. There were also conflicting work styles among the users. Some users felt discouraged in using the lab in a collaborative capacity because they were asked to be quiet, while other users liked the CL^3's quiet work environment.

The survey also included a section for users to provide suggestions to improve the lab. Combined with the observations, suggestions included improving the signage concerning hours, equipment, and ways to move the workstations. Providing easily accessible information at the workstation to inform the user that this is a collaborative space was a big concern. Users also wanted more hours to use the lab; increasing the number of staff may help remedy the problem. Also the number of workstations limits the amount of people that can be in the space and the amount of collaboration. Incorporating laptop use into the space may help facilitate more groups to work in the lab. Also, printing options were suggested to accommodate the need to print on legal sized paper. Users had the opportunity to present tangible improvements to the CL^3 lab.

4.2. Limitations

Although the survey method was employed to facilitate an unbiased method of collecting data, the participation was voluntary with no reward and as a result people could have stopped answering the survey at any time. People who took classes in CL^3 were forced into collaborative groups, so they were required to use the CL^3 in a collaborative function. Students in classes were more aware of the design of the lab than a typical user. Thus, the collaborative function of CL^3 was being utilized but a number of users were not aware of all the features. Thus, information about the various uses of the CL^3 may provide and encourage the CL^3 users to use the space in a more collaborative sense.

5. Conclusion

In conclusion this study assessed the physical design of CL^3 in relation to physical comfort, collaboration, user demographics and user preference for the design aspects and technology in this space. A wide range of majors were represented in the CL^3 users. A third comprised of women, 50% of whom were from the engineering department. Survey on user preference showed that the top two reasons CL^3 was preferred were because a class took place there and the comfort and aesthetics of the space.

The anthropometric dimensions of the furniture, force requirements for moving furniture, posture of users and noise levels were captured and discussed in the physical ergonomics section. In summary it was found that adjustments will need to be made by the user depending on where they fall in the anthropometric range and CL^3 furniture does allow for that. However it is important to educate the user about the correct posture and how the workstation should be adjusted to suit them. Noise levels were found to be low during non class times. Although the force required to be encouraged to move a workstation is not known the force required to move them were not at a level where there is a risk of injury in the case that they are moved.

Although flexibility of the furniture was taken into consideration during the design stage of CL^3 lab, 37% of users who never moved the furniture did not do so because were unaware that moving furniture was allowed or that they were movable in the first place. Education and encouragement for users to fully utilize the flexibility of the lab for their collaborative work should be explored in future. Some recommendations include putting up posters to encourage people to move furniture around, bigger wheels which appear to be easier to move, and handles on tables suggesting it is a movable workstation.

Observations of CL^3 and the Runway found that groups in the Uris Runway showed a higher level of collaboration in terms of a more equal spread of interactions per person in a group. The sound level in the Uris runway was also found to be higher. This may indicate a higher level of interaction though the mean observation score of interaction for the two spaces were similar. It is suggested that some physical design aspects of the Runway may contribute to this higher observed level of interaction. This may be the informal nature of the space, the availability of different types of furniture, openness and flow of people.

The survey indicated that more people rated dual screens as ‘important’ than the dual keyboards and mice which were rated most frequently as ‘somewhat important’. This was confirmed from observations where there was found to be a dominant user of the keyboard and mouse within each group in CL^3. Usually the secondary keyboard and mice were set aside and rarely used.

Overall we feel the goal of creating a space that facilitates collaborative learning during class times has been met by CL^3. The aspects that respondents think are important for collaborative work are mostly present in CL^3. We feel that to enhance collaboration outside of class times, some suggested design changes can be made. The design of more organic spaces such as the Runway could also inform this process.

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7. Appendix

7.1. CL^3 Survey Results

1. **I am a(n)…**
   51 – Undergrad
   2 – Graduate
   2 – Other
   - High School student
   - Lecturer

   1 Left blank

2. **I major in…**
   12 – CS
   3 – CIS
   40 – Other
   - BEE (3)
   - Chemistry
   - Independent Major (3)
   - Economics
   - A&EP
   - Mechanical Engineering (2)
   - History/Film
   - Computing in the Arts
   - TXA
   - ORIE (5)
   - Hotel
   - Biology (2)
   - Communications
   - AEM
   - English (2)
   - Fine Art
   - Near Eastern Studies
   - Art/Info. Sci.
   - ECE (3)
   - MBA
   - High School
   - Unaffiliated/Undecided
   - Left blank (6)

   2 Left blank

3. **I am…**
   18 – Female
   35 – Male
   4 Left blank

4. **Why do you use the CL^3 Lab? (Tally refers to the number of people that answered "yes" to each question.)**
   27 – Because I have to for my class
   22 – I use it for other classes/class work
   13 – To hold group meetings for class
   17 – For free computing time
   20 – Because of the software offered here
   22 – Because of the option to use double screens/keyboard/mouse
   19 – Because there is adequate space to meet in groups
   18 – Because the location is convenient
   27 – Because the lab is aesthetic or comfortable
   6 – Because I can move the workstation around
   6 – Other
      - "I used to meet there for CIS490"
      - "large amount of desk space"
      - "Other labs are stressful, suffocating"
      - "i come with my friend"
      - "I borrow DV cameras from there"
      - Left blank

5. **When working on a group project, how much of your group time is spent in task-related conversation?**
   3 – None
   19 – Some of the time
   28 – Most of the time
   0 – All of the time
   7 Left blank

6. **Of the class time you spending CL^3, how much time do you spend collaborating with other students?**
   11 – None
   1 – A little bit (<30%)
   11 – A moderate amount (30 – 70%)
   20 – A lot of the time (70% +)
   14 Left blank

7. **Of the time you spend outside of class in CL^3, how much time do you spend collaborating with other students in other computer labs?**
   13 – None
   19 – A little bit (<30%)
   8 – A moderate amount (30 – 70%)
   6 – A lot of the time (70% +)
   11 Left blank

8. **How many people usually work with you at a workstation when you are doing collaborative group work in CL^3?**
   7 – One person
   14 - Two people
   15 – Three people

5 – Four people
1 – Five people
0 – Six people
0 – Seven people
0 – Eight people
2 – Nine people

9. How would u rate the importance of the following items for collaborative work in any computer facility?

	Not important	Somewhat important	Important	Very important	Left blank
Ability to customize work area by moving chairs, tables, and computers	7	16	12	10	12
Ability to work with others on the same computer	3	11	19	12	12
Ability to work with others on multiple computers	2	13	20	10	12
Quiet conditions to help with concentration and conversation	5	18	14	8	12
Ability to discuss projects freely without fear of disrupting others	2	6	21	17	11
Having partitions (such as screens or movable walls)	18	14	7	5	13
Having open space	2	14	19	9	13
Having dry erase boards	6	12	19	6	14
Having 2 screens	6	16	16	7	12
Having 2 keyboards	6	28	8	3	12
Having 2 mice	6	22	12	4	13
Being able to overhear other groups	24	16	2	3	12
Being able to see other groups	24	15	3	3	12
Being visually removed from other groups	26	12	5	2	12

10. Has anything deterred you from entering CL^3?
29 – The door was locked
25 – Times on the door indicated that the lab was closed
8 – There were too many people there for my comfort
14 – There were too few computers available for my use
1 – The room was too hot/cold for me
5 – A person told me not to come in
2 – The professor wasn't there
1 – It didn't look comfortable and/or conducive to work

3 – It was too noisy
5 – Other
- "Class would be starting soon"
- "I am not taking any class that uses CL^3"
- "i couldnt tell if i could go in"
- "Staffing issues"
- "Closed although times said should open"

11. How often do you rearrange the computer tables in CL^3?

2 – Every time I go to the lab
3 – Most of the time when I go to the lab
16 – Some of the time
6 – Only when I am told to
20 – I've never moved the tables
10 Left blank

12. Why have you moved the tables?

1 – So that people can't see me or my work
2 – To avoid disturbing others by talking
2 – To avoid being disturbed by others talking
7 – I needed more space for work
7 – I was instructed to move it
9 – To be closer to/father from the whiteboard/screen/other
18 – To create a better work arrangement
16 – To improve collaboration with others
4 – For fun
19 – I've never moved the tables

13. If you have not rearranged the computer tables in CL^3 before, why not?

7 – I didn't know it moves
10 – I didn't know I was allowed to
17 – I don't need to
0 – They are too heavy
0 – They look too heavy
0 – There wasn't enough space
2 – I don't think moving the table helps collaboration
4 – I didn't want to bother others
3 – I would feel too embarrassed
0 – The equipment wiring limits table movement
0 – The computer beeped too loud when unplugged
2 – Other
- "Just wasnt something I've needed to do"
- Left blank

14. How did you find out the tables were movable?

10 – I was told by an instructor
0 – I was told by another user
19 – I figured it out myself

10 – I saw others move them
8 – I didn't know they were movable

15. Would you move the table more often if:

11 – It was lighter
16 – It was easier to plug and unplug the cables?
17 – There were fewer wires?
2 – The computer didn't beep when unplugged
8 – The wheels moved more easily?
0 – It had a smaller tabletop?
9 – Others were doing it more often?
5 – I had help from another person to move it?
11 – There were signs suggesting to move the tables?
2 – It was more like a cart?
3 – The lab had laptop computers instead of desktops?
13 – I wouldn't
2 – Other
- "signs: How to Move Tables & Replug"
- "Random positioning of stations"

16. How often do you adjust the following furniture?

	Every time when I go to the lab	Most of the time when I go to the lab	Some of the times when I go to the lab	Only when I'm told to	Left blank
Chair height	11	9	22	3	12
Screen viewing distance	8	12	22	3	12
Screen angle	9	11	23	2	12

17. How does your group use the following dual items in CL3?

	Don't use it	Use one	Use both	Left blank
Screen	4	7	32	14
Keyboard	4	23	16	14
Mouse	4	23	16	14

18. Do you ever:

	Never	Some of the time	Most of the time	Always	Left blank
Feel crowded in CL^3	19	22	4	1	11
Lose concentration due to the number of people in CL^3	21	22	1	1	12
Feel your privacy is affected by the number of people in CL^3	28	15	2	1	11
Have your work affected by noise levels in CL^3	29	13	2	0	13
Feel your group work is affected by the number of people in CL^3	30	11	3	0	13

19. Do you feel that the signage within the lab gives accurate, adequate information about:

	No	Needs improvement	Satisfactory	Yes	Left blank
Lab schedule	3	14	18	9	13
Lab functionality	4	11	21	9	12
Lab equipment/software	4	14	18	7	14

20. Do you have any suggestions for improving the signage within the lab for more accurate, adequate information about lab schedule, functionality, equipment or software?

- "I can't honestly think of any signage other than the schedule on the door (which is usually wrong). Maybe more visible signage."
- "post hours clearly, signs explaining how to safely move & replug tables, list of software generally available, list of available resources"
- "Having working audio of most of the computers would help, I often cannot hear the work I am working on. The projecter is often braking and is making it hard to present projects."
- "it would be great (I don't know if it's possible) if both ppl could type at the same time and the each mouse had a different icon on the screen, that way someone could work on one screen, someone on the other, and it would be easy to share that work."
- "Have a larger sign that is more visable and not so ambiguous when it is closed. Just post open hours like most people do"
- "List of available software/equipment on small cards (possibly on every desk)"
- "Not really, I rarely go to CL^3 anymore."
- "no"
- "No, I feel the signage is adequate."
- "no"
- "I cannot recall seeing much signage in the lab referring to functionality, epquiment or software. My suggestion would be to make these signs more visible and apparent to those who are using the lab."
- "No"

- "Relocate CL3 to a room that has a more squared surface area. The room height wise is perfect, but its width is to narrow…making it seem like a rectangle, which makes it hard for everyone to see the board."

21. What suggestions would you give for improving CL^3 to make it a more collaborative space?

- "The lab is already a great collaborative space. I can't think of any obvious improvements."
- "Make it more apparent that it is not a quiet study room or something along those lines because sometimes people work in there and have the false assumption that making noise in there is frowned upon or just are rude and ask you not to talk to group members even though that's one of the main functions of the room. A sign like 'Talking encouraged, but be polite' would be nice."
- "More hours!"
- "Forget the dual monitor / keyboard / etc systems. Most people don't use that feature; it would be much more beneficial to have 2 computers rather than 1 of these (because there are a lot of ppl who want to work in this lab)
- "A projector that did not shutdown in the midst of presenting."
- "more hours open"
- "Have more space to gather around the tables, more movable table space to gather around."
- "Really love this place :D"
- "People occasionally come here and converse about asanine, non-work related things in load voices."
- "As I mentioned before. Allow longer hours or cut down the CS classes. A lot of people want to use this lab but they can't because there are CS classes here for like 5 hours every day and lab hours are quite limited. There is also space to add an extra station. The tables could be reduced to 2/3 of what they are now and that would allow for a few extra stations but please do take privacy into account by adding some movable isolation elements."
- "A coffee machine."
- "fine for me"
- "expand the lab to somewhere bigger, possibly extend hours, more printing options like 11x17 printing"
- "I was just told that due to 'staffing problems' I would have to finish up and leave within the next 15 minutes, but was welcome to come back in 2+ hours when they hope to reopen. That is a definite deterent from my future use."
- "More hours – why not open at 8 am and run past midnight?"
- "get the projector to work!"
- "I feel that the lab would improve if headphones and other audio equipment were provided."
- "None."
- "More computers"
- "Greater surface area…the height of the class room is fine."

22. What features do you enjoy about CL^3?

- "Dual screens, adjustable workspace, casual environment, ease of collaboration."
- "Fast computers. Open spaces. Nice software set. White boards. Etc."
- "double screens and mobile furniture allow people to create custom work spaces"
- "I really like CL^3"
- "Open, fun, collaborative & possible to interact with other people"
- "Movable work stations, dual screens, duel mouses."
- "everything"
- "Defintly the dual screens"
- "Its more private and less known than the other computer labs within Uris Runway, which is nice because you can still go to the library where most of your friends are yet, actually get work done in this lab. I also, like the large desk space and high celings."
- "Dual screens, open space, time to work, wireless, programs/software, lots of electric outlets for more laptops."
- "everything. Especially the fact that it's not oppressive, crowded, stuffy, hot, and dimly lit like the other labs."
- "Fast and reliable equipment, comfortable chairs, generally quiter and more comfy than other computer labs."
- "The high ceiling."
- "two screens"
- "2 screens, 2 mice, moveable workstations"
- "I like how I can save stuff on the computer and it won't be deleted."
- "Dual screens, nice computers, whiteboards, collaborative environment."
- "looks awesome, is awesome"
- "Spacious and work-oriented environment"
- "I enjoy the movable tables and the dual monitor/keyboard/mouse."
- "the computers are fast and the large screens and double keyboards/mice are nice for partner work"
- "The overall comfort ability of it and the dual screens/mice/keyboards."
- "I enjoy the double screens in the lab as they are better suited to encourage collaborative work."
- "The double-screen"
- "Height of the room."

23. What features do you dislike about CL^3?

- "CL^3 should be bigger. It's a great lab, but can only support a limited number of people effectively."
- "The hours."
- "Not a lot of information available."
- "Projector."
- "some chairs don't roll very well (not a big problem)"
- "The tables are really heavy"
- "The confusing schedule regarding its hours of operation. It should be open all the time like the other labs and only unaccessible when there is a class held in that lab."
- "Locked Tuesday/Thursday mornings from 11-12"
- "Being asked to leave when there are 10 CS kids occupying only two stations while there are another 6-7 stations"

- "It's in an old-looking building. It's the kind of room that should be in Duffield or something. But that's mostly irrelevant."
- "hi tech"
- "not enough computers sometimes, printers do not print out larger pages (11x17)"
- "I hate the odd hours. I hate how the lab monitors sometimes just shut down the lab without warning even though the lab is supposed to be open. I've had so much frustration from trying to work around the strange hours of this lab, causing me to currently turn in a project 9.5 hours late. Since it's the only place at Cornell that has 3d studio max, I have no choice but to come here."
- "there is only one CL^3 station on campus!"
- "Not as comfortable chairs"
- "I don't like that it closes sometimes; occasionally I like to work late at night but it has been closed before when I wanted to work."
- "there are not many computers"
- "I dislike that the white boards at the front of the room do not erase entirely, thus making it difficult to ready what was written on them. Additionally, the markers are often too dry to write legibly with. However, I am satisfied with the technological equipment available in the lab."
- "It's a large room, I prefer less wide open space."
- "The surface area of the room."

7.2. Summary of comments

20. Do you have any suggestions for improving the signage within the lab for more accurate, adequate information about lab schedule, functionality, equipment or software?

- More visible signs and correct information on signage outside door, because its usually wrong
- Post hours clearly and visibly!! (this was repeated over and over)
- Signs explaining how to move desks and equipment
- List of software and resources generally available
- Better projector that doesn't break as often!!! (This was stated over and over as well)
- Working audio on more computers
- If each of the two mice could have separate icons on the screen
- If people could type at the same time

21. What suggestions would you give for improving CL^3 to make it a more collaborative space?

- Expand hours!! (this was repeated over and over!)
- Don't hold so many CS classes in it
- More workstations
- Movable isolation elements
- More space to gather around the tables
- A sign saying something like, "talking encouraged but remember to be polite"
- Make people aware of the fact that it's a collaborative space
- Do away with dual monitors

22. What features do you enjoy about CL^3?

- Dual work screens!! (said over and over again)
- Mobile furniture
- Fast and reliable computers
- White board space
- Software set!! (Said a lot of times)
- High ceilings
- Comfy chairs
- It's more private than the other computer labs in Uris, so you can go to the library where your friends are but still get stuff done.
- Large desk space
- Lots of outlets
- Open/fun/possible to interact with other people
- Less crowded and stuffy than other labs

23. What features do you dislike about CL^3?

- Being asked to leave when CS classes are being held there and the students in the class are not fully utilizing every computer
- The Hours!!! (said many, many times)
- The headphones – they need more modern, more comfortable headphones
- Locked on Tues/Thurs mornings
- Confusing schedule – it should just be open all times of day, like the other labs, except when class is being held in there
- The chairs don't roll very well
- Tables are really heavy
- The projector
- There is not a lot of information available about what the lab has to offer
- Needs to be bigger
- Gets stuffy when lots of people are in there, such as during class times

Appendix 7.3 Collaboration Observation Data

Observation Data Sheet in **CL3**

Group Number	Location	People in Room	Time	Record time(min)	Person	Key Board	Mouse	Talking	Keying	Mousing	Pointing at Screen	Pointing at Paper	Writing
1	CL3	9	5:30 PM	10	A	Left	Left	13	0	0	1	0	0
					B			24	0	0	0	0	0
					C			18	14	4	0	0	0
2	CL3	n/a	10:55 AM	10	A	Left	Left	21	9	34	3	0	0
					B			28	0	0	16	0	0
3	CL3	n/a	11:05 AM	10	A			7	6	10	2	0	0
					B	Right	Right	10	0	0	0	0	0
4	CL3	8	10:45 AM	10	A		Left	38	0	14	2	0	0
					B	Right	Right	33	5	20	0	0	0
5	CL3	10	3:50 PM	10	A	Left	Left	10	23	15	0	0	0
					B	Right	Right	13	2	3	0	0	0
					C			5	0	1	1	0	0
6	CL3	6	4:05 PM	7	A		Right	19	0	3	3	0	0
					B			13	0	0	4	0	8
					C			4	0	0	1	0	8
					D			12	0	0	6	0	0
7	CL3	6	4:17 PM	10	A			2	0	0	2	0	15
					B		Right	18	0	1	6	0	0
					C			8	0	0	3	0	0
					D		Left	23	0	12	7	0	0
8	CL3	5	6:30 PM	10	A			21	4	7	1	0	0
					B			10	0	0	1	0	0
					C			9	0	0	3	0	0
					D			11	3	10	2	0	0
					E			21	1	4	1	0	0
9	CL3	2	6:00 PM	10	A			16	0	9	1	0	0
					B			18	0	3	4	0	0

Observation Data Sheet in **CL3** (Cont'd)

Total Talking	Percentage of talking	Interaction by person*	Total Interaction	Percentage of interaction	Coefficient of deviation	# of interaction per minute	Total keying and mousing	Keying and mousing by person	Percentage	Difference of percentage**
55	23.64%	14	56	25.00%	7.34%	5.60	18	0	0.00%	100.00%
	43.64%	24	56	42.86%			18	0	0.00%	
	32.73%	18	56	32.14%			18	18	100.00%	
49	42.86%	24	68	35.29%	14.71%	6.80	43	43	100.00%	100.00%
	57.14%	44	68	64.71%			43	0	0.00%	
17	41.18%	9	19	47.37%	2.63%	1.90	16	16	100.00%	100.00%
	58.82%	10	19	52.63%			16	0	0.00%	
71	53.52%	40	73	54.79%	4.79%	7.30	39	14	35.90%	28.21%
	46.48%	33	73	45.21%			39	25	64.10%	
28	35.71%	10	29	34.48%	9.89%	2.90	44	38	86.36%	84.09%
	46.43%	13	29	44.83%			44	5	11.36%	
	17.86%	6	29	20.69%			44	1	2.27%	
48	39.58%	22	62	35.48%	10.23%	8.86	3	3	100.00%	100.00%
	27.08%	17	62	27.42%			3	0	0.00%	
	8.33%	5	62	8.06%			3	0	0.00%	
	25.00%	18	62	29.03%			3	0	0.00%	
51	3.92%	4	69	5.80%	14.90%	6.90	13	0	0.00%	84.62%
	35.29%	24	69	34.78%			13	1	7.69%	
	15.69%	11	69	15.94%			13	0	0.00%	
	45.10%	30	69	43.48%			13	12	92.31%	
72	29.17%	22	80	27.50%	6.17%	8.00	29	11	37.93%	27.59%
	13.89%	11	80	13.75%			29	0	0.00%	
	12.50%	12	80	15.00%			29	0	0.00%	
	15.28%	13	80	16.25%			29	13	44.83%	
	29.17%	22	80	27.50%			29	5	17.24%	
34	47.06%	17	39	43.59%	6.41%	3.90	12	9	75.00%	50.00%
	52.94%	22	39	56.41%			12	3	25.00%	
				Mean coefficient of deviation	8.56%					
				Average # of interaction per minute		5.80			**Average difference of percentage**	74.94%

Note: * Interaction is the sum of the number of talking, pointing at screen and pointing at paper.

** Difference of percentage is the difference between the highest percentage and the lowest percentage within the group.

Observation Data Sheet in **Uris Runway**

Group Number	Location	People in Room	Time	Record time	Person	Key Board	Mouse	Talking	Keying	Mousing	Pointing at Screen	Pointing at Paper	Writing
1	Uris	10	4:30 PM	10	A			18	0	3	0	0	0
					B			17	0	0	0	2	1
					C			16	6	19	0	0	0
2	Uris	n/a	4:45 PM	10	A			30	0	0	2	0	7
					B			30	12	2	6	1	0
3	Uris	12	4:58 PM	10	A			26	17	16	3	0	0
					B			8	0	0	0	0	0
					C			17	0	0	0	0	0
					D			24	0	0	0	0	1
4	Uris	13	2:25 PM	10	A			26	16	21	0	0	0
					B			25	0	9	1	0	0
5	Uris	13	8:05 PM	10	A			23	0	0	0	4	0
					B			15	0	0	0	0	0
					C			15	0	0	0	0	0
					D			14	0	0	0	0	0
					E			10	0	0	0	0	0
					F			16	0	0	0	0	0
6	Uris	23	11:10 AM	5	A			14	0	14	0	0	0
					B			16	0	0	0	0	0
7	Uris	n/a	9:40 AM	10	A			6	23	16	4	0	0
					B			6	0	0	0	0	0
8	Uris	15	5:00 PM	5	A			11	5	2	0	0	2
					B			19	2	4	1	0	0
					C			11	7	1	0	0	0
9	Uris	n/a	5:00 PM	10	A			13	13	7	1	2	0
					B			16	0	0	1	4	0
10	Uris	n/a	4:30 PM	10	A			9	0	0	2	0	0
					B			10	11	7	2	0	0
					C			13	0	1	3	0	0

Observation Data Sheet in **Uris Runway** (Cont'd)

Total Talking	Percentage of talking	Interaction by person*	Total Interaction	Percentage of interaction	Coefficient of deviation	# of interaction per minute	Total keying and mousing	Keying and mousing by person	Percentage	Difference of percentage**
51	35.29%	18	53	33.96%	2.35%	5.30	28	3	10.71%	78.57%
	33.33%	19	53	35.85%			28	0	0.00%	
	31.37%	16	53	30.19%			28	25	89.29%	
60	50.00%	32	69	46.38%	3.62%	6.90	14	0	0.00%	100.00%
	50.00%	37	69	53.62%			14	14	100.00%	
75	34.67%	29	78	37.18%	10.12%	7.80	33	33	100.00%	100.00%
	10.67%	8	78	10.26%			33	0	0.00%	
	22.67%	17	78	21.79%			33	0	0.00%	
	32.00%	24	78	30.77%			33	0	0.00%	
51	50.98%	26	52	50.00%	0.00%	5.20	46	37	80.43%	60.87%
	49.02%	26	52	50.00%			46	9	19.57%	
93	24.73%	27	97	27.84%	5.37%	9.70	0	0	n/a	n/a
	16.13%	15	97	15.46%			0	0	n/a	
	16.13%	15	97	15.46%			0	0	n/a	
	15.05%	14	97	14.43%			0	0	n/a	
	10.75%	10	97	10.31%			0	0	n/a	
	17.20%	16	97	16.49%			0	0	n/a	
30	46.67%	14	30	46.67%	3.33%	6.00	14	14	100.00%	100.00%
	53.33%	16	30	53.33%			14	0	0.00%	
12	50.00%	10	16	62.50%	12.50%	1.60	39	39	100.00%	100.00%
	50.00%	6	16	37.50%			39	0	0.00%	
41	26.83%	11	42	26.19%	10.10%	8.40	21	7	33.33%	9.52%
	46.34%	20	42	47.62%			21	6	28.57%	
	26.83%	11	42	26.19%			21	8	38.10%	
29	44.83%	16	37	43.24%	6.76%	3.70	20	20	100.00%	100.00%
	55.17%	21	37	56.76%			20	0	0.00%	
32	28.13%	11	39	28.21%	5.54%	3.90	19	0	0.00%	89.47%
	31.25%	12	39	30.77%			19	18	94.74%	
	40.63%	16	39	41.03%			19	1	5.26%	
				Mean coefficient of deviation	5.97%					
				Average # of interaction per minute		5.85	**Average difference of percentage**			82.05%

Note: * Interaction is the sum of the number of talking, pointing at screen and pointing at paper.

** Difference of percentage is the difference between the highest percentage and the lowest percentage within the group.