5/8/01

The Usability and Ergonomics of Chairs in the Center for Computer-Assisted Language Instruction

Melissa VanderBok
Nathan M^{c}Kimpson

May 8, 2001

Dr. Jack Jobst
Associate Professor of Humanities
Michigan Technological University
1400 Townsend Drive
Houghton, MI 49931-1209

Dear Dr. Jobst;

This letter is in regards to the ergonomic study that was conducted on the chairs in the CCLI. Attached you will find a copy of the report

First of all, we would like to apologize for failing to contact you in a timely fashion regarding the ergonomic study. We greatly appreciated you working around your busy schedule to attend our presentation last week.

Our study concluded that the majority of the chairs currently in the CCLI are not able to conform to current ergonomic standards. This is mainly caused from the various adjustment mechanisms on the chairs being broken and not from users poor working habits. The details of our study are discussed further in the attached report.

This study was conduced to determine if the chairs in the CCLI are adequate to promote the goals of the CCLI. We appreciate you taking the time to read our report and we hope that it provides you with a clearer picture of the current condition of the chairs in the CCLI. If you have any questions regarding our study, feel free to contact us.

Sincerely,

Nathan M^{c}Kimpson nmmckimp@mtu,edu
Melinda VanderBok mavander@mtu.edu

CC: Dr. Dale Sullivan, Michael Moore

Table of Contents

List of Appendices (Only Appendix E is included in the PDF version)

Abstract

In order to determine whether the chairs in the CCLI provide an effective and healthy working/learning environment we have conducted an ergonomic study. We addressed the following concerns in our ergonomic study:

- Are the chairs used in the CCLI helping or impeding productivity?
- Are the chairs affecting the health of CCLI users?
- Are CCLI users concerned with the comfort and cost of the chairs used?

A usability test was conducted in three parts.

- A functional observation of the most popular chair model in the CCLI. The observation checked the 23 SteelCase chairs located on the Mac-side of the CCLI. We tested the four adjustable features (upper-back support, chair-depth, chair-height, and back angle). If they did not work the reason was noted. (See Appendix A)
- Interviews with CCLI users. We interviewed three graduate students and five undergraduate student users of the CCLI. The people interviewed answered two short questionnaires (See Appendix B) as well as participate in a performance test on Model 430-520.
- Performance test on the four adjustable features of Model 430-520. Eight CCLI users were asked to participate in a speak-aloud protocol while adjusting the chairs.

Our usability test shows that the graduate students more so than the undergraduates found that the chairs currently used in the CCLI were unsatisfactory. Although only one of the eight students interviewed mentioned health problems caused by the chairs in the CCLI, there were seven respondents to a survey sent out by Cherry Ball, about health problems caused by chairs in the CCLI. People who responded to the email survey reported injuries ranging from numbness, aching joints and carpal tunnel syndrome. Overall, most people surveyed would like to see an improvement in the seating of the CCLI, and mentioned that easy adjustably, range of adjustments, lower and upper back support as well as armrests were a primary concern.

Introduction

Usability can be defined as the process of improving the interaction between humans and technology. One way that this interaction can be improved is through ergonomics. Ronald Guillemette defines ergonomics as '…involving the design, implementation and use of technical information to accommodate human limits, constraints, and characteristics" (Guilemette, 218) We used this definition of ergonomics while evaluating the usability of the computer chairs used in the Center for Computerized language Instruction (CCLI.)

In order to determine whether the chairs in the CCLI provide an effective learning and working environment, we have conducted an ergonomic study. This study focuses on the ergonomic impact of the chairs currently available in the CCLI and whether or not they meet, or can be adjusted to meet, current ergonomic standards.

Context of Use

The environment that the CCLI chairs are used in directly effects how they are used. Because the users of the chairs we tested work in the CCLI seated at computers, we felt that it was necessary to test the chairs in this environment. Therefore, we conducted our usability test in the CCLI, using the most popular chair found in the CCLI. In our preliminary survey on how people use the chairs in the CCLI, we interviewed and took photographs of a number of people working in the lab. We wanted to accurately determine how people use the CCLI so we asked people for a picture and their initial reactions before describing the topic of our usability test and the adjustable features that the chairs have. Because people act differently in unfamiliar surroundings we felt that conducting our test in the CCLI would give the most accurate results.

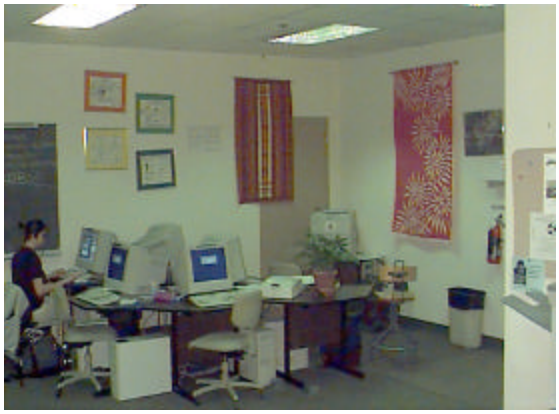

Figure 3.0: PC Side of the CCLI

Using an unfamiliar environment or representative users, instead of actual users, may not produce the same reactions that actual users experience. This difference in reactions could be because of a number of factors:

- The participant may be more nervous sitting in a strange environment
- The participant may not have the same social interactions with the other participants
- The user may want to use the lab in a different way

- The layout of the space may have been different causing people to move and interact less.

Because the CCLI has a lively and social atmosphere it was important to conduct our usability test in this environment. The interactions we saw taking place between the CCLI users and their chairs played an integral role in the development of our usability study. For example, we noticed that many users were switching chairs often to talk to friends or moving frequently from one chair to another so we added this question to our Post-Test Survey in order to find the reasons why this occurs.

An unfamiliar environment, or representative users may not have the same everyday reactions. This could be because of a number of factors. The user may be more nervous sitting in a strange environment, the user may not have the same social interactions with the other participants, and the layout of the space may have been different causing people to move and interact less.

Methodology

Our usability test was designed to address the following areas:

- Are the chairs used in the CCLI helping or impeding productivity?
- Are the chairs affecting the health of CCLI users?
- Are CCLI users concerned with the comfort and cost of the chairs used?

We accomplish this by observing CCLI users, asking participants to answer a pre-test questionnaire (see Appendix B), conduct a think-aloud protocol while testing the four adjustable features of a chair, and concluding our test by asking each participant to answer a short follow-up questionnaire (See Appendix C). We also conducted a functional observation on the 23 SteelCase chairs located on the Mac-side of the CCLI.

After talking to the actual users of the CCLI we made a qualitative assessment on how people use the CCLI and what improvements (or lack of) they would like to see in the future. The functional observation allowed us to quantitatively assess the condition of the CCLI's chairs. Although we tested fully functional chairs during our performance test, it is important to note that many of the chairs do not have all of the adjustment features that were tested.

Participants

We asked three graduate and five undergraduate CCLI users to participate in our usability test. Because they are actual users of the lab, we hoped to accurately assess how the lab is used by each of the participants. We chose participants ranging in ages from 20-45. The participants in our survey were users who we see frequently in the lab (greater than four days a week) and those that we see in the lab less frequently (less than four days per

week). We also decided to test both graduate and undergraduate students in our study because these groups each use the lab differently and testing both of them would allows us to gain an more complete understanding about how the chairs are really used.

Test Day

On Saturday, April 28th, 20001 we conducted our usability test on the ergonomics of the CCLI chairs. The test was conducted in the following manner.

1) Inventory on the Chairs used in the CCLI.
2) Functional observation of the four adjustable features on the most popular model (SteelCase, Model 430-520.)
3) Interviews and think aloud protocols
   a) Gather participants
      - Sign waivers
      - Pre-test Surveys
      - Performance tests
      - Post-test surveys
      - Informal interview
4) Exit Test

CCLI Chair Inventory

The purpose of doing an inventory on the chairs used in the CCLI was to assess the type of chairs available to CCLI users and what the chairs are being used for.

We documented the following criteria:

- Make of chair
- Serial Number
- Location of Chair
- Mac or PC side (In front or not in front of a Computer)
- Quantity or number of each type of chair
- Year the chair was purchased

Figure: 1:0: SteelCase Model 430-420, the most common chair found in the CCLI

By documenting the chairs used in the CCLI hoped to determine what chairs the CCLI users have to choose from and what chairs the CCLI users prefer to use.
(See Appendix D for results)

Functional Observation

After determining the types of chairs used in the CCLI, we found that one model, SteelCase Model 430-420, comprised 73.9% of the CCLI chair makeup. There were 23 chairs of this make in use on both the Mac and PC floor. We tested the four adjustable features of each 430-420 chair on the Mac side in order to determine the durability of this model as well as test the adjustable features in order to see how functional the chairs currently are. (See Appendix E for adjustable features) The adjustable functions of model 430-420 are:

- Chair height adjustment; the height if the seat from the floor.
- Back support adjustment; the height of the back-support cushion in relation to the seat (vertical motion).
- Back depth adjustment, the location of the back of the chair to the seat (horizontal motion).
- Back angle adjustment; the angle of the upper pad from its vertical position (90° from horizontal).

Pre-test Survey

After a quick briefing on what a usability test was, and describing their role in the test, each of the eight participants were asked to fill out a five question preliminary questionnaire.

The questions that we asked were:

1) Are you a(n): (please Check one)
   - ❑ Undergraduate Student
   - ❑ Graduate Student

2) On average, how much time do you spend per day in the CCLI?

3) Do you feel that the chairs in the CCLI are adequate to support and effective learning environment? Why or why not?

4) What does the term “ergonomics” mean?

5) Describe your ideal chair. What features do you look for? What features would you try to avoid?

The purpose of our Pre-test survey was to assess how each participant uses the lab, as well as to determine how informed each participant is about the subject matter of our test.

Performance Test

After filling out the Pre-test survey, each participant was then asked to participate in a performance test. The performance test served four purposes:

- To test the chair's overall ease of use (as far as the four adjustable feature)
- To determine the participants overall knowledge about the adjustable features of the chair (chair height, back support, back depth and back angle)
- To determine if the adjustable features were adequate, in terms of providing a comfortable chair.
- To establish a repair with each participant and encourage them to elaborate on their usage of the chairs in the CCLI

We asked the participants to adjust each of the SteelCase 430-520 chair's adjustable features. During the testing process we encouraged the participants to vocalize their thoughts as well as any other comments they may have about the chairs in the CCLI.

An outline of a typical interview session:

1) Testing Chair Adjustably (same for all four features)

    a) (Before Adjusting) Did you know that you could adjust that chair's height? Will you give it a try?
    b) (While Adjusting) Participants were prompted with questions like, Why did you turn the chair over? Why do you think that (what they are doing) will work? What are you thinking now?

2) Follow up Questions (asked after the participant has attempted to adjusts all four adjustable features)

    a) Now that you know what's adjustable, will you ever adjust your chair in the future?
    b) Which of the features is the most useful?
    c) Which feature would you change and what would you like to see as far as adjustable features on your perfect chair?
    d) Why did you choose to sit in this (referring to the chair the participant in currently using) particular chair?

Post-test Survey

After the participants completed their performance test, they were asked to answer a five question post-test survey. The questions that we asked were:

1. Please rate the CCLI chairs in the following areas and explain. (1-10, 10 being highest)
    - Overall Comfort
    - Overall Ease of Use

- Overall Satisfaction

2. Have you ever had any health problems that may have been caused by the chairs in the CLLI? What would help fix these problems? Please explain.

3. Do you ever switch chairs in the CCLI? If so, why and how often?

4. Do you have any additional comments about seating in the CCLI?

5. How important are the chairs in the CCLI to you?

The purpose of the post-test survey was to determine how the participants feel about the chairs in the CCLI. This was accomplished by asking for numeric ratings about various properties of the chairs and other questions dealing with how participants feel about the chairs in the CCLI. We also, wanted to use this portion of our usability test to address the issue of health problems that may have been caused by the chairs in the CCLI.

Data and Discussion

CCLI Chair Inventory Data and Discussion

An inventory of the chairs used in the CCLI reveals that one model, SteelCase Model 430-520 made up 73.0% of the 58 chairs found in the CCLI. Of the other model chairs found in the CCLI, the only two not located in front of computers were wooden or stool-like chairs. (See Appendix F) Two undergraduate participants specifically mentioned the SteelCase Model 1283 as a "chair of choice." The most common reasons that the students gave for preferring Model 1283 to the standard 430-520 are:

- "Fairly often I get a broken chair so I generally switch to the yellow chairs because they're more stable.
- "The yellow chairs have a generous seat and higher back support."

Figure 2.0: SteelCase Model 1283

Functional Observation Data and Discussion

Checking the adjustable features on the 23 SteelCase, Model 430-520, chairs we found on the Mac-Side of the lab revealed that 53.8% of the chairs on the Mac-side have one or more broken adjustable features. (See Appendix G)

Chair Height Adjustment

The chairs tested in the CCLI were all fully adjustable in terms of seat-height. The chairs can be adjusted for seat-height by twisting the chair seat clock or counter-clockwise. Model 430-520 has a height adjustment range of 4.25". The chair's seat can be adjusted anywhere from 17" to 13.75" above the ground. This is an acceptable height only for CCLI users who are less than 5'8" tall. According to the Cornell University Ergonomics Lab, "You should be able to adjust the height of the seat sot that the front of your knees is level or slightly below level and your feet are firmly on the ground." (http://ergo.human.cornell.edu/AHTutorials/chairch.html.) The state of Minnesota's Department of Employee Relations states that an ideal seat height is 16"-20" off the ground. (http://www.doer.state.mn.us/ei-safih/Seating/wcrit99c.htm)

Back Support Adjustment

Only 7.69% of the Model 520-420 chairs tested had a broken back support adjustment feature. (See Figure H) In all cases, the height of the back pad was stuck in one position and the button controlling this feature was stuck in a fully depressed position.

The range of motion for this back support is two inches. This movement for the back-support cushion has no mid-rage. The cushion locks in place only in the upper and lowermost positions. The height of the back support in its highest position is 16 inches above the lower seat cushion. The suggested range for the back-support cushion is eight inches, with the position of the back-cushion, ranging from 20" to 28" above the seat. (http://www.doer.state.mn.us/ei-safih/Seating/wcrit99c.htm)

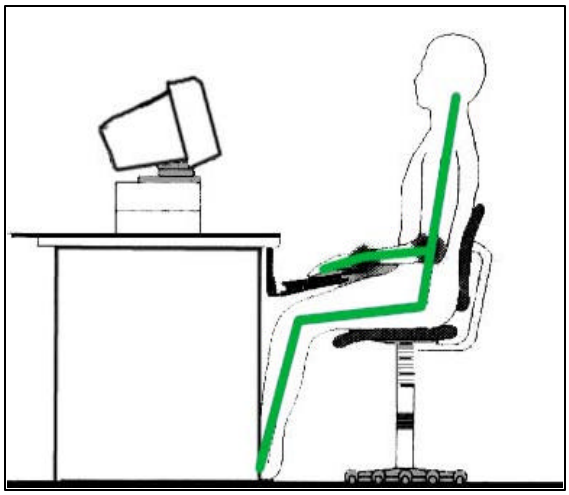

Figure 4.0: Ergonomically Correct Posture

Back Angle Adjustment

38.4% of the 23 chairs tested in our functional observation had a broken back-recline function. (See Appendix H) A quarter of the broken chairs could be fixed by replacing

the screw that is used to adjust the angle of recline. In many cases, the screw was stripped or missing leaving the adjustment option useless.

The maximum range of motion for Model 430-520 is 25°. This is an acceptable range, as most ergonomic studies suggest a range from 90°-110° from the ground. (See Figure 4.0, the person pictured is sitting 110° from horizontal)

Although the chair has an acceptable range of motion, the chair back becomes unsteady when the seat-depth adjustment is locked somewhere other than the lowest position (position nearest to the seat). In its lowest position, the back cushion overhangs he seat by 1.5", forcing the user to sit at an 85° angle.

Seat Depth Adjustment

The feature that was most commonly broken on Model 430-520 was the seat depth adjustability. 38.4% of the chairs tested were broken. Of these, all could be fixed by replacing the screw that controls this function. Three of the nine screws are stuck, resulting in the seat being locked in one position. The rest are stripped or missing, as a result the seats not completely locked into position, resulting in an unstable back.

Conclusions and Recommendations

The data collected from our study shows that the majority of the chairs in the CCLI are currently not providing users with the correct amount of support and adjustment they need while working in the lab. Based on the results we reached three conclusions about the current chairs in the CCLI:

1. There have been health problems related to the chairs in the CCLI
2. Most people would like to see new chairs in the CCLI
3. These new chairs should include the following features:
    - Armrests
    - Lower/Upper back support
    - Easy Adjustably features (with a larger range)
    - Durability

The current chairs were adequate when they were originally purchased but they have become worn down after years of repeated use. Many of the adjustable functions of the chairs no longer function correctly so that users cannot adjust them properly. Working for extended periods of time in an improperly adjusted chair can cause a varied of physical ailments such as muscle fatigue and carpal tunnel syndrome.

Implementing these recommendations will help insure a productive and safe working environment for CCLI users for years to come.

References

Guillemette, Ronald, *Usability in Computer Documentation Design: Conceptual and Methodological Considerations*, IEEE Transactions on Professional Communication, vol. 32, No. 4, December 1989.

Cornell University Ergonomics Web, http://ergo.human.cornell.edu/, Accessed on 4/19/01

F-One Ergonomics web site, http://www.office-ergo.com/ergonomi.htm, Accessed on 4/17/01.

Minnesota Department of Employee Relations web site, *State Safety and Industrial Hygiene Unit Ergonomic Training Manual: Criteria for Ergonomic Seating and Accessories,* http://www.doer.state.mn.us/ei-safih/Seating/wcrit99c.htm, Accessed on 4/14/01.

Appendix E – Picture of the Common CCLI Chair

Figure 5.0 - The four adjustable features of Model 430-520 that were tested during the functional observation are shown above. Each of the participants in our usability test was asked to adjust the same four features.