INTERNATIONAL JOURNAL OF HUMAN–COMPUTER INTERACTION, *22*(3), 247–269

What Frustrates Screen Reader Users on the Web: A Study of 100 Blind Users

Jonathan Lazar
Aaron Allen
Jason Kleinman
Chris Malarkey
Department of Computer and Information Sciences, Towson University

In previous research, the computer frustrations of student and workplace users have been documented. However, the challenges faced by blind users on the Web have not been previously examined. In this study, 100 blind users, using time diaries, recorded their frustrations using the Web. The top causes of frustration reported were (a) page layout causing confusing screen reader feedback; (b) conflict between screen reader and application; (c) poorly designed/unlabeled forms; (d) no alt text for pictures; and (e) 3-way tie between misleading links, inaccessible PDF, and a screen reader crash. Most of the causes of frustration, such as inappropriate form and graphic labels and confusing page layout, are relatively simple to solve if Webmasters and Web designers focus on this effort. In addition, the more technically challenging frustrations, such as screen reader crashes and conflicts, need to be addressed by the screen reader developers. Blind users in this study were likely to repeatedly attempt to solve a frustration, not give up, and not reboot the computer. In this study, the blind users reported losing, on average, 30.4% of time due to these frustrating situations. Implications for Web developers, screen reader developers, and screen reader users are discussed in this article.

We acknowledge Dr. Betsy Zaborowski, Brad Hodges, and Chris Danielsen, all from the National Federation of the Blind, for their assistance in participant recruitment and data collection. We also thank Jessica Lawrence, who was involved in early stages of participant recruitment, and Jared Smulison and Ellen Libao, who ensured that participants got paid for their participation. Finally, we appreciate the assistance of Jinjuan Feng with technical issues.

This material is based upon work supported by the National Science Foundation under Grant 0414704. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Correspondence should be sent to Jonathan Lazar, Department of Computer and Information Sciences, Center for Applied Information Technology, Universal Usability Laboratory, 8000 York Road, Towson, MD 21252. E-mail: jlazar@towson.edu

1. INTRODUCTION

The stated goal of many governmental and private efforts is to create universal access to the resources of the Web. However, universal access to the Internet and Web is meaningless if the users continuously become frustrated and cannot actually use the resources available to them. Universal usability is one step beyond universal access, ensuring that all users can actually find the technology usable (Shneiderman, 2000). To reach the goal of universal usability, it is important to understand user diversity. When the problems that different user groups face are examined, it is possible to make user interfaces that can address the needs of most, if not all, user populations.

A number of previous research studies have examined the frustrations and errors of typical users, either student users or workplace users. The goal of this study is to expand on the previous research by examining the frustrations of blind users who use screen readers to browse the Web. This research study provides a number of contributions to the research: to learn more about the specific causes of frustration on the Web for blind users, to learn how blind users respond to these frustrating situations, and to learn how much time is perceived as being lost by blind users due to these frustrating situations.

2. BACKGROUND LITERATURE

2.1. User Frustration Research

There are a number of previous studies exploring the errors and frustrations that users of computing technology face on a regular basis. Historically, this work grew out of the early work in human–computer interaction on the errors that users make. One of the best-known articles on user error is from D. Norman (1983), who created a taxonomy of the various types of errors made by users. Throughout the 1980s and 1990s, the research examined various aspects of error: training methods to address error (e.g., Dormann & Frese, 1994; Frese et al., 1991; Nordstrom, Wendland, & Williams, 1998), errors in older users and users with motor impairments (Carroll & Carrithers, 1984), documentation (Lazonder & Meij, 1995), and the design of error messages themselves (Shneiderman, 1982). These studies helped researchers understand what errors users typically make and how to improve interfaces, training, and documentation to try and limit error. We know from this research that interfaces should not present phrases in error message dialog boxes such as "a fatal error" or an "illegal operation."

Over time, the research work has expanded from the focus of error to the focus of computer frustration. Frustration is a broader concept than error. An error is when there is an incorrect or perceived incorrect state of the system (Ceaparu, Lazar, Bessiere, Robinson, & Shneiderman, 2004). Frustration is a broader category because there are many things that occur during correct states of the system, and these things annoy users. These frustrations, such as annoying pop-up boxes, unclear dialog boxes, and hard-to-find features, do more than just annoy users. These frustrations waste user time. When users in a workplace are frustrated with their computers, it can lead to lower levels of job satisfaction (Murrell & Sprinkle, 1993). In some cases, user frustration with technology can even lead to increased blood volume pressure and muscle tension (Hazlett, 2003; Riseberg, Klein, Fernandez, & Picard, 1998). These frustrations reduce the productivity of employees, the profitability of companies, and sales on e-commerce Web sites (Lazar, 2006). There is even potentially an impact on mood and relationships with others (Lazar, Jones, Hackley, & Shneiderman, 2006a). It is not surprising that an estimated 80% of users have cursed at their computer (K. Norman, 2004).

This research study builds on the work of two previous research studies on frustration. In one study with students, and one study with workplace users, the frustrations that these users faced as well as the time lost were examined through the use of a time diary (Ceaparu et al., 2004; Lazar, Jones, & Shneiderman, 2006). It was reported that users waste an average of 37% to 50% of the time spent on the computer due to frustrating experiences. Most of the major causes of frustration, such as unclear error messages, hard-to-find features, and pop-up windows, are interface-related problems, which are problems that, with appropriate planning and user involvement, can be engineered out of the system. These frustrations not only have an impact on the productivity of the users but also had a negative impact on their mood (Lazar, Jones, Hackley, & Shneiderman, 2006). Sometimes even simple changes to the interface design can have a major impact on user productivity and frustration. For instance, when a government Web site for statistics was examined, users reported high levels of frustration and low levels of task completion (Ceaparu, 2003). When the wording of link labels were changed, performance nearly doubled and frustration levels dropped (Ceaparu & Shneiderman, 2004). Given that frustration *can* be addressed and at least somewhat alleviated, it is important to learn more about what frustrates various user populations, with the end goal of lowering frustration.

2.2. Assistive Technology

Users with disabilities are a specialized, but large, user population. It is estimated than more than 50 million people in the United States have a disability, and 10% to 20% of the world population has some type of disability (Paciello, 2000; Slatin & Rush, 2003). Throughout the world, it is estimated that at least 6 million people have some form of visual impairment that hinders the use of traditional computer displays (Ghaoiu, Mann, & Ng, 2001). Although there is no exact count of the number of blind computer users, a majority of blind individuals that are employed do use computers in their work.

Many of these users with impairments utilize various assistive technology devices. The assistive technologies generally focus on alternative approaches to input or output. Some of the assistive technology devices include alternative keyboards and pointing devices, speech recognition, eye tracking, Braille displays, and screen readers (Paciello, 2000). Screen readers are the most popular assistive technology utilized by users with visual impairment (either full visual impairment or partial visual impairment). Because Braille literacy rates are low, speech output is the most common assistive technology for users with visual impairment (Zhao, Plaisant, Shneiderman, & Lazar, 2006). In addition, other assistive technology tools for the blind, such as tactile displays, are prohibitively expensive. Screen readers are software packages that, working with computer speakers, read what is displayed on the computer screen out loud, in computer-synthesized speech. Two of the most popular screen readers are JAWS and Window-Eyes. There are also simple versions of screen readers built into some operating systems.

There have been a number of attempts to enhance screen readers. For instance, a math markup language was created to help users of screen readers better understand math formulas (Karshmer & Gillian, 2005). Although this is very helpful for a small subset of blind users, this is not widely used. Another tool, called BrookesTalk, is an integrated screen reader and Web browser tool (Zajicek, Powell, & Reeves, 1998). The objectives of BrookesTalk were to provide a more stable integrated environment and more navigational information about the content on a Web page (through structuring and markup of the content on the page by the application). Although these are excellent enhancements for screen reader users, they are not widely used by blind computer users. The majority of blind computer users still use either Window-Eyes or JAWS.

Most blind users do type into a keyboard, as they have the keyboard layout memorized and do not need to see the keyboard to use it. Therefore, it is the output, not the input, that is most challenging for blind users. Although the use of screen readers is common, users with visual impairment can use a Web page only when it is designed to be flexible, that is, to be used in conjunction with various forms of assistive technology.

2.3. Web Accessibility and Usability for Blind Users

A number of interface design guidelines currently exist to help Web developers make their Web pages accessible for users with disabilities. The two most commonly used accessibility guidelines are the Web Content Accessibility Guidelines (http://www.w3.org/wai) and the Web accessibility guidelines from the United States Federal Section 508 (http://www.section508.gov). These guidelines are used by government as well as private companies and organizations. These guidelines tend to cover the interface needs of most users with perceptual or motor impairment; however, they do not yet address the needs of users with cognitive impairment. In many countries, Web-based information provided by the government must be made accessible (Slatin & Rush, 2003). The topic of frustration for computer users with disabilities is becoming more important, as government policy enforces the rights of users with disabilities to have access to certain types of Web-based information. In many countries, including the United States, Canada, Portugal, Australia, and the United Kingdom, computer users with disabilities have the right to access all government information on the Web in an accessible manner (Slatin & Rush, 2003). The scope of these laws is only increasing. For instance, the U.S. Department of Transportation has a proposed new rule that would require all airlines to make their Web sites fully accessible. In addition, the Attorney General of New York State announced that the Web sites of travel companies in New York State are required to make their Web sites accessible, as these travel Web sites count as "public accommodations" and are therefore covered under the Americans with Disabilities Act (Office of the New York State Attorney General, 2004).

Despite the existence of these guidelines as benchmarks and despite the government policies encouraging accessibility, most nongovernmental Web sites do not follow these accessibility guidelines. Depending on the category of Web site (e.g., e-commerce, nonprofit, educational, etc.), Web site accessibility is generally no greater than 10% to 20% of Web sites (Lazar, Beere, Greenidge, & Nagappa, 2003; Loiacono & McCoy, 2004; Sullivan & Matson, 2000). Part of the challenge seems to be the misperception among Webmasters that an accessible Web site must necessarily degrade the experience for visual users (Lazar, Dudley-Sponaugle, & Greenidge, 2004). In addition, Webmasters and designers always feel pressure to upgrade their Web sites and add more technically advanced features. Because these updates are generally made without any concern for accessibility, many sites, over time, actually become less accessible (Hackett, Parmento, & Zeng, 2004; Lazar & Greenidge, 2006).

Aside from the general level of accessibility, which means that a site technically works for a user with a disability, it is also possible to go one step further and examine the usability, not only technical functionality, of a Web site for a user with a disability. Although a Web site might be accessible for a blind user, it still might be very hard to use. For instance, the information on the Web page may be arranged in such a layout that blind users become frustrated in attempting to access the information. Many pages contain multiple columns or redundant links, which require a blind user to read each Web page in a line-by-line fashion. With each selection of a link, users must start from the top of the page in reading until they either reach the bottom of the page or find a desired link. The selection of a new link refreshes the screen, which generally forces screen readers to move focus to the top left-hand corner of the screen. The frustration occurs when users must listen to the same information each time they choose a new link.

Another example of this is the use of "banners" that cause the screen to refresh every time there is a change in the banner text. This may cause screen-reading software to lose focus and often results in the user hearing information that is not at the position of the cursor. These are informally reported frustrations for blind users that utilize screen readers to browse the Web, but no previous studies have examined and documented the problems that blind users face.

3. RESEARCH METHODOLOGY

There are many potential methods for collecting data on user frustrations. Users can be asked to fill out surveys some time after they have completed their computer usage session. Users can also be interviewed to ascertain what frustrations occurred. The weakness of both of these methods is that they ask people to remember exactly what occurred, and people tend to overestimate or underestimate events that occurred in the past. Data logging is also problematic for recording frustrations, as the computer can only record events that are identified by the computer as errors—which may be very different from how users perceive instances of frustration (Lazar, Meiselwitz, & Norcio, 2004; Rubin, 2001). The use of time diaries to track user frustrations has proven to be the most effective method of gaining information (Ceaparu et al., 2004). Time diaries allow for a more accurate assessment of the frustrations that computer users face as they surf the Web. The results are not biased by the user's recollection of events; instead they are captured in real time and therefore have higher levels of validity than surveys (Czerwinski, Horvitz, & Wilhite, 2004) . Users can record their feelings regarding frustrating events as they occur (Lazar, Meiselwitz, & Norcio, 2004). Time diaries have proven to be more accurate than retrospective time estimates because users record their time lost immediately as the losses occur rather than attempting to remember the information at a later time (Robinson & Godbey, 1997). Although there are inherent limitations to any type of human-recorded data collection, as biases and perceptions come into play, overall, time diaries are a better method of data collection for working with the blind.

The study presented here used data collection methods that were pioneered in previous research on user frustration. In two previous studies, the frustrations of users relating to their computers were examined using the time diary data collection method. One study examined the frustrations of student users (Ceaparu et al., 2004), and the other study focused on workplace users (Lazar, Jones, & Shneiderman, 2006). In both studies, participants recorded their frustrations with their computer interactions using a modified time diary. Participants recorded their frustrations during a multihour session of computer usage. Before starting their session, the participants filled out demographic information and questions relating to presession mood. Every time that the participants felt frustrated, they filled out a frustration experience form (see Appendix A) and noted the cause of the frustration, how they responded to the frustration, the time lost, and their mood. At the end of the session, participants filled out a postsession form, noting their mood.

Because this methodology and the data collection forms for the time diary had already been tested and validated, it was decided that this would be the best approach for data collection. Furthermore, it offered the advantage of some comparisons across the various research studies. However, due to the different user population and the different focus of the research, a number of modifications would be required.

The first modification made is that fully electronic forms were used for data collection. In the previous studies, either paper forms or a combination of paper and electronic forms were used to record the time diaries. This was not possible, as handwriting is not a primary form of communication for blind users, and the handwriting of most blind users would be hard to decipher. Requiring forms to be filled out in Braille was not be feasible, as both Braille literacy is low (an estimated 20% of blind users) and the printers necessary to print Braille are expensive and not widely available. It was clear that an electronic form was the best way to collect data.

Because this study focuses on accessing the Web, we felt that using a Web-based method of collection would create more frustration for a blind computer user if problems occurred in accessing the Web. If for any reason the Internet connection went down or the Web browser crashed, there would be no way of recording a potential substantial source of frustration for the user. If the user could not connect, the online Web-based form would be totally useless. When users gets frustrated with the Web, they should not be forced to record their frustrations by actually using the Web, as that would create a multiplier effect, increasing the level of frustration. Therefore, a non-Web-based electronic form was the best way to collect data for this study.

The second modification to the form was that wording of some questions were changed to be more appropriate for studying blind users on the Web. Because this study was focused not on general computer frustration but rather on specialized frustration with the Web, the responses to some close-ended questions were modified or limited. In addition, new questions related to screen readers, type of training, and perceptions of accessibility were added to the time diary forms.

Once developed, these forms were then tested for technical functionality as well as for wording. Experts in the field of assistive technology as well as a few blind users took part in the pilot testing of these time diary instruments. A few modifications to wording were made; however, the greatest changes took place in the technical implementation of the forms. Because blind users work in multiple technical environments (OS, platform, processor, screen reader), these forms had to work 100% the same in all environments. Therefore, thorough testing of these forms took part in multiple technical environments. In early testing, it was discovered that the form features in Microsoft Word tended to crash both major screen readers. In addition, one of the pilot testers did not have the appropriate version of Word. It seemed that Word versions of the forms were not going to work for most users. Therefore, forms were next tested in rich text format, which, although losing the form controls, did offer much more reliability in multiple platform/OS/screen reader combinations. In testing, the RTF forms did work in all technology combinations attempted.

Once the forms were developed and ready, participants needed to be recruited for the study. We began by setting up a recruitment table at the National Federation of the Blind Convention in Atlanta, Georgia, in July 2004. The National Federation of the Blind is one of the collaborators on this study, and we recruited for this study with their full approval. At the convention, name, address, phone, and e-mail information was collected from anyone who indicated an interest in taking part in the study. Fliers were distributed, in Braille, at the convention. In addition, announcements were sent out over e-mail listservers sponsored by the National Federation of the Blind.

Starting in September 2004, the actual study forms were sent out to all who indicated a willingness to participate. The electronic forms were sent out to all participants over e-mail, and they were required to be returned using e-mail. However, at the request of the National Federation of the Blind, documentation on the study could be sent in alternative formats. All data were collected using the electronic forms. Although Braille literacy is low (an estimated 20% of blind people), there are some that prefer to receive reading material in Braille, and Braille versions were available upon request. In addition, large-print versions were also made available upon request. There are a small number of users who have partial visual impairment but use screen readers. However, the larger percentage of people that want large print do so because their helpers can read the materials to assist them. The visual impairment community is diverse and their needs are diverse, and by allowing the forms and instructions to be sent in multiple formats, it allows for ultimate flexibility.

There was one form that, due to university requirement, had to be sent in paper format: the Human Subjects and Payment form. Before individuals could participate in the study, the university required that participants acknowledge and sign that they understand that they are taking part in a research study, they understand their rights, and they know that they may discontinue participation in the study at any time. This form is also used to process payment for participation (all participants were paid a small stipend for participation). Despite the fact that a signature is not the best method of data collection for people with visual impairment, the state government and university mandated a written signature on this form. Although electronic versions of the form were sent so that the blind users could read and understand the forms, Braille labels were used so that the participants would know where to sign. The Braille labels were thick, clear plastic and said "sign above" in Braille. Although some participants might not have known what the Braille labels said, the instructions indicated that the labels said "sign above" and all participants could use the labels to know where the signature should go.

One final note related to the research methodology: There are a few instances in the Results section where numbers do not add up to the 100 participants or 308 frustrating experiences. These are generally due to participants either underreporting (not filling in a certain question) or overreporting (answering multiple responses to one question, where only one response is requested). Although some of these can theoretically be enforced using form field controls, when we originally tested the use of form controls within Word, they caused problems with the screen readers, in some cases causing the screen readers to crash. Therefore, we chose to use rich text format for entry rather than form controls. The downside of this is that it lowers the control of incoming data. At the same time, the RTF form does not in any way cause screen reader problems or crashes, which could cause increased frustration levels and time wasted, and therefore influence the data recorded. Using the rich text format without any form controls was the best way to ensure that our forms themselves did not add any additional frustration.

4. RESULTS

4.1. Demographics of Participants

From September 2004 through May 2005, 100 users with visual impairment submitted time diaries. There were 61 female participants and 39 male participants who took part in the study. The average age of participants was 43.37 years (SD = 12.5 years). The age range was from 18 to 81 years. Two additional participants took part, but their data were not included. One participant's data were incomplete, and the other participant's data were not included due to technical difficulties. Participants reported an average of 8.06 years on the Web (SD = 3.91 years), an average of 13.31 years on the computer (SD = 5.14 years), and an average of 31.34 hr a week on

Table 1: Highest Completed Education Level of Participants

Highest Level of Education	*Level*
Some high school	0
High school graduate	2
Freshman or sophomore in college	18
Junior or senior in college	3
College graduate	35
Masters degree	30
Doctoral/professional degree	10

Note. Two participants did not report their education level.

the computer (*SD* = 16.63 hr). The highest completed level of education for participants is presented in Table 1. Of the 98 participants that responded to the question, 75 participants had, at minimum, a bachelor's degree. This is representative of the population of blind computer users. Although not all blind individuals use computers, those that do tend to have a high level of education.

Computer usage is closely linked to employment and education for blind individuals. In addition, participants were asked if they had received any type of computer-specific training. In this data, 43 participants indicated that they had not received any formal training; 15 participants indicated that they had received blindness-adjustment training; 30 participants indicated that they had received specialized screen reader training; and 22 indicated that although they did not have any formal training, they had mentors who assisted them. More details on the training is provided in Table 2. As previously mentioned, participants in some cases did report more than one response (meaning that they had received more than one type of training), so the number of responses to this question is 110.

4.2. Technology Environment

Of the 100 participants, 84 participants indicated that they use the JAWS screen reader, 12 participants indicated that they use the Window-Eyes screen reader, and the other 4 participants indicated that the use other screen readers. Table 3 presents the operating systems reported by users. The participants primarily used Windows

Table 2. Computer Experience as it Relates to Type of Training Received

	Average No. of Years on Computer	*Average No. of Hr per Week on Computer*	*Average Age*
No formal training—my own	13.7	33.5	45.3
No formal training—mentors	13	30.9	42.7
Blindness adjustment training	10.5	26.1	38.5
Screen reader training	13.8	29.5	43.6

Table 3: Operating Systems Reported by Users

Operating System	*Number of Times Cited*
DOS	1
MacOS	1
Unix/Linux	1
Windows 95	0
Windows NT	1
Windows 98	22
Windows ME	6
Windows 2000	15
Windows XP	60

Note. In 9 cases, users indicated that they use more than one operating system. Additionally, two users did not indicate which system they used.

98, Windows 2000, or Windows XP. This is not surprising, as a majority of assistive software for blind users is developed for the Windows operating system.

4.3. Causes of and Responses to Frustration

The 100 participants submitted information on 308 frustrating experiences (an average of 3.08 frustrating experiences per person). Table 4 displays the causes of frustration. Because the causes of frustration are inherently qualitative data, a structured content analysis was used to analyze the data. Five researchers took part in this content analysis, and data were examined multiple times to best determine the intent of the participants. In situations where, after content analysis, the cause of the frustration was still unclear, the cause of the frustration was labeled as "other." The top causes of frustration were (a) page layout causing confusing screen reader feedback; (b) conflict between the screen reader and application; (c) poorly designed/unlabeled form; (d) no alt text for pictures; and (e) a three-way tie between misleading links, inaccessible PDF, and a screen reader crash.

Table 5 indicates how users reported responding to the frustrating experience. The most common responses were, I was unable to solve it (110), I knew how to solve it because it has happened before (54), I ignored the problem or found an alternative solution (48), and I figured out a way to fix it myself without help (39). Table 6 indicates how often users reported these frustrations occurring. Participants reported the following: First time it happened (77), Several times a week (51), More than once a day (43) and Several times a month (36).

Table 7 reports on how all of these frustrating experiences made the participants feel. Participants reported feeling Other (91), Helpless (82), Determined to fix it (81) and Angry at the computer (55). Table 8 reports on the level of frustration for each frustrating experience. The average level of frustration was 6.71 ($SD = 2.08$), which is relatively high. The frustration scale ranged from 1 (*not very frustrating*) to 9 (*very frustrating*). Therefore, if there was a low amount of frustration or no frustration, the average should be around 1. An average level of 5 could be considered to be "somewhat frustrated", and yet the average frustration score is close to 7.

Table 4. Causes of Frustration

Causes of Frustration	*Number of Occurrences*
Alt Text	
No alt text for pictures	18
No alt text for pictures-required registration	5
Nondescriptive alt text	10
Links	
Misleading links	15
Link not working	3
Couldn't find link	5
No skip navigation	3
Forms	
Poorly designed/unlabeled form	23
Plug-ins	
Inaccessible Portable Document Format (PDF)	15
Inaccessible Flash	12
Java applets causes problems	3
Active X not working	1
Windows Media Player/Real Audio not working	8
Navigation	
Auto-refresh causes screen reader to continually restart	5
Broken back button	4
No frame name	2
Timed out	1
Can't find info	2
Mouse required for navigation	1
Layout	
Page layout causing confusing screen reader feedback	36
Pop-up frustration	13
Table won't read linearly	1
Failures	
Screen reader crash	15
Couldn't connect to server	4
404-file not found	6
Computer freeze	4
Find feature (on page) not working	2
Conflict between screen reader and application	28
E-mail server down	2
Application/network conflict	1
Slow web site download	7
Other	49
Total	304

Note. In four frustrating situations, the user didn't record the cause of the frustration.

4.4. Time Lost

Another goal of this study was to document the average time lost by screen reader users due to their frustrating situations. Users, in general, spend more time recovering from an incident than initially working through the incident. Both the initial time spent on responding to the frustrating experience and the time to recover from

Table 5: Summary of How Participants Responded to the Frustrating Experiences

How Did Participants Respond to the Frustrations?	*n*
I was unable to solve it	110
I knew how to solve it because it has happened before	54
I ignored the problem or found an alternative solution	48
I figured out a way to fix it myself without help	39
I asked someone for help	32
I tried again	18
I rebooted	15
I restarted the program	7

Table 6: Summary of How Often Participants Reported These Frustration Experiences Occurring

How Often Did This Type of Frustrating Experience Occur?	*n*
First time it happened	77
One time a day	10
More than once a day	43
Once a week	29
Several times a week	51
Once a month	21
Several times a month	36
Several times a year	31
Didn't respond	10

Table 7. Summary of How These Frustrating Experiences Made Users Feel

How Did the Frustrating Experience Make You Feel?	*n*
Angry at the computer	55
Angry at myself	19
Helpless	82
Determined to fix it	81
Neutral	36
Other	91

Table 8. Average Level of Frustration

Level of Frustration in an Experience[a]	*n*
1	3
2	9
3	17
4	20
5	38
6	33
7	52
8	53
9	83

[a]1 (*low*) to , 9 (*high*). $n = 308$.

any work lost due to the problem contribute to the total time lost. The method for computing percentage of time lost per user is as follows:

$$\text{Percent Time Lost} = (\text{MS} + \text{MR}) \ / \ \text{MT}$$

where MS is minutes spent to solve the problem, MR is minutes spent to recover lost work, and MT is total minutes spent on the computer (Ceaparu et al., 2004).

This is the method for calculation that was used in two previous studies on user frustration for student and workplace users. To calculate the overall statistic, the amount of time lost was normalized for each user, and the percentage time lost for all users was then averaged. This statistic provides the more representative view of what each user was experiencing and helps minimize the impact of outliers. In addition, to be able to perform comparisons across studies, we kept this method of calculation, as the previous studies also used this calculation method. A total of 30.4% of time spent on the computers, as tracked by the time diary, was wasted due to frustrating experiences. The time data from only 90 users were included, as 10 users indicated that they wasted more than 100% of time. It is theoretically possible to lose more than 100% of the reported time spent during the session. For instance, in an extreme example, if you spent 2 hr on the computer and your hard drive crashed, you would have lost more than 100 hr of work. This is obviously an extreme example, and nothing like this occurred within the current study. However, it is possible that someone spent 3 hr on the computer but, due to a crash, lost work from a previous session and therefore lost 110% of their time. Although it is possible, we consider situations where users report losing more than 100% of their time to be outliers and would prefer to be conservative when reporting our data. We have therefore removed those outliers from the data reporting. This is the same method that was used to remove outliers in the previous research on user frustration.

Another approach to analyzing time lost is not to normalize the time lost by each participant, but rather to sum the minutes lost for all participants and then divide that by the minutes spent on the computer for all participants. If this alternate method for computing time lost was used, the time lost would be computed as 31.0%. Therefore, this is a pretty robust statistic.

4.5. Other Statistics

Note that it was impossible to determine if there were any differences in performance or frustration related to the type of training received by users in their previous experience. Blind users sometimes receive a specialized type of computer training on using a screen reader and may receive computer training as a part of blindness adjustment training. Although the question was asked on the time diary about the type of training received, the participants that took part in this study in many cases reported having multiple types of training. It was therefore not possible to determine the exact type of training received. In addition, there was a statistically significant difference in the number of years of Internet experience depending on the type of training indicated, $F(3, 96) = 4.19$, $p < .01$. Users with no formal training (learned on their own) had the longest time on average using the Internet (9.56

years), whereas users with no formal training (had mentors) had the shortest time on average using the Internet (6.16 years). Users with blindness adjustment training had 7.88 years on average using the Internet, whereas users with specialized screen reader training had 7.39 years on average using the Internet.

Table 2 displays other demographic information presented by training method, although these were not statistically different. Based on both the lack of controls on training and on the demographic differences among training reported, it is impossible to make any conclusions related to how training influences user performance or frustration.

5. DISCUSSION

The results of this data collection tell an interesting story about the frustrations that blind users face on the Web.

5.1. Causes of Frustration

Many of the most frequently reported causes of frustration are actually relatively easy for Web designers to solve. For instance, in the top causes of frustration discussed in this article, it is relatively easy to improve the labeling of forms, improve the labeling of links, add appropriate alternative text for pictures, improve the clarity of page layout, and make PDF files accessible. There are well-known solutions for these problems, which can be done quickly with a limited amount of technical skill. The challenge here is to educate Web developers, as well as Webmasters, about the importance of this issue. In addition, although it is technically easy to change wording or provide alt text or form labels, it is important to determine what wording should be used so that users will be able to understand it. Traditional usability engineering methods (even quick and inexpensive methods such as card sorting and paper prototyping) will be helpful in solving these types of problems (Nielsen, 1994). The two other causes of frustration will be more challenging to solve. The conflict between screen reader and application and the screen reader crash are technically much more complex to solve and have technical roots rather than usability roots.

In the previous paragraph, the most commonly cited causes of frustration were discussed. However, there were many, less frequent causes of frustrations that need to be addressed. The frustrations were categorized as alt text, links, forms, plug-ins, navigation, layout, failures, and other.

There were a number of causes of frustration related to alt text. In some cases, alt text was missing; in other cases, alt text was present but nondescriptive (e.g., "picture here"). A third and worrisome category is where there is no alt text for a picture that is required viewing to register on a site. To avoid spammers and other automated techniques, some Web sites are now requiring that users view the text that is in a picture and then type in that text to verify their registration. This is not the best way of ensuring actual validity of the registrant, as many users will not be able to view the picture if they are blind. For these sites, an alternative, audio version of the phrase in the picture must be supplied. This is still not ideal, as there can be many spellings of an identically pronounced word, depending on the usage.

Participants reported a number of different frustrations related to links. A majority of these were misleading links, where the label does not accurately describe where the link will take the user. Although visual users tend to read the links in context of the surrounding text, many blind users access a list of links rather than read through the entire page, where the link is removed from the context of the surrounding text. This increases the problem of link labels that are confusing or unclear (e.g., "click here" or "this link" or "take me there"). These misleading link labels also can make it so that users cannot find the link that they are looking for. Participants in this study also complained about the lack of skip navigation. Skip navigation is where a link is provided on a Web page, before the navigation is listed, where users can click to "skip over" the navigation links so they do not have to hear them every time, when in reality they want to skip ahead to the page content (see Figure 1). It is a simple, added link that can make the Web experience less frustrating for users, although it is usually presented in a way in which a visual user cannot see the link; only users with a screen reader will hear the link and will have the option to skip over the navigation choices and get to the main content.

The problem of appropriate wording and labeling also applies to the category of forms. A common frustration among participants in this study was that Web-based forms were either poorly labeled or not labeled; a form field simply had no named label or had a misleading label, such as "field3." Although "field3" is technically a label, it does not provide any useful information to the user who is listening to the form.

Plug-ins can sometimes be frustrating for blind users. A plug-in is a separate application that runs during the Web browsing to deal with a certain type of external file. There can be three problems: The plug-in itself might not be accessible, the file being accessed through the plug-in might not be accessible, and there might be a conflict between the plug-in and the screen reader. For instance, the blind participants in this study reported frustrations with PDF (Adobe Acrobat), Flash, Java ap-

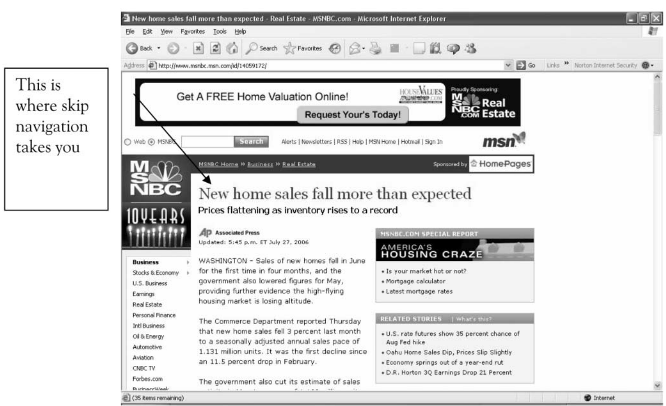

FIGURE 1 An example of skip navigation.

plets, Active X, and Windows Media Player and/or Real Audio. However, the specific causes of frustration for each of these are different. For instance, Adobe Acrobat files can be 100% accessible for blind users. However, the PDF files must have been created using a newer version of the Adobe Acrobat PDFwriter. So if a PDF file was created a long time ago, it will probably need to be re-created. Although Flash currently is not accessible, Macromedia has been working on making Flash more accessible. Java applets can be accessible; however, most Java is not written to be accessible, and it is possible that the applets will crash the browser (or the screen reader), as this frequently happens with visual users (Lazar, Meiselwitz, & Norcio, 2004). For the remaining plug-in frustrations, the plug-ins themselves (such as Windows Media Player) should be accessible, so it might be either a file accessibility problem or a conflict between the plug-in and the screen reader and/or the operating system

Web navigation is sometimes a problem for blind users. Although these navigation-related frustrations were not cited as often as some of the other frustrations, they do provide a useful window into how site navigation can be improved for blind users. For instance, when standard navigational components of the Web browser are disabled by the Web site, this can be problematic. Users may count on the Back button for some navigation-related use, and if that Back button is disabled, the user will have one less navigational tool at their service. Another example of a problematic navigation-related frustration is if the page is set to auto-refresh, every, say, 2 min. If auto-refresh keeps refreshing the page, the user will need to repeatedly listen to the same Web page information and may never get to the end of the page. Users can also have problems with navigating Web frames if the frame names are nondescriptive, such as "left frame" or "top frame." Blind users who are listening to a Web page with a screen reader need more descriptive frame names, such as "main content" or "search engine" or "navigation."

Page layout closely relates to navigation, except that it tends to focus on navigation of a specific page rather than the navigation between pages on a site. One of the biggest causes of frustration cited by participants in this study was that the page layout causes confusing screen reader feedback. When a blind user reads through a Web page using a screen reader, they read through the page linearly (serially), one column at a time, one line at a time, one word at a time. Most visual users read through a page by connecting all of the various objects and words that are placed close together on a page. Features such as tables and frames are frequently used in Web page layout to help control the page layout. This means that designers use words or objects in different frames or tables, with the idea that those frames or tables will cause the words or objects to be displayed in proximity. For blind users, they read through each table, each frame, each line, one at a time. The context of that neighboring information is lost. It is sometimes hard to determine where within the Web page the user is located. This was mentioned as a frustration by participants very frequently (36 instances). Web designers need to be aware that tables and frames, when used improperly, can cause these problems. Another page-navigation-related problem is pop-up boxes. Although most users, visual or not, do find pop-ups to be frustrating, pop-up boxes cause a special type of frustration for blind users. For blind users, the pop-up box will appear, read through, and then typically reset the screen reader to start reading what appears at the top of the page. So the user gets, say, halfway down a page with the screen reader, gets a pop-up menu, and then heads back to the beginning of the page. The screen reader then starts again, hits another pop-up menu, and is forced to the beginning of the page. It is easy to understand why pop-up boxes are problematic for blind users.

The most technologically challenging frustrations to solve are those related to failures. Although most of the previously mentioned frustrations were caused by usability problems (and can be fixed with appropriate usability methods), the frustrations in the last category are caused by technological failures. These failures include screen reader crashes, computer freezes, conflicts between screen readers and applications, 404-file not found errors, and various other features not working or connecting. These are not problems that can be solved easily. However, some of these problems, especially those that are not network-related problems, can be improved. For instance, more thorough testing of screen reader applications before they are released to the public could help ensure that the screen readers are less likely to crash and are more likely to interface properly with commonly used applications.

5.2. How Participants Responded to Frustrations

The blind participants in this study responded very differently to the frustrations than the visual users in previous studies. In the workplace study, visual users most commonly reported that (a) they responded to the frustrating experience by restarting the program or rebooting or (b) they knew how to solve it because it has happened before. In the student study, users responded that they knew how to solve it because it has happened before or that they were unable to solve it. In both of these studies, users knew how to respond to the frustrating situation, gave up, or were unable to solve the situation. Although the blind users in this study also frequently reported that they were unable to solve the problem, users frequently indicated (in 87 frustrating experiences) that they found an alternative solution or figured out a way to fix it without help more frequently than instances where they knew how to solve it because it has happened before. Furthermore, restarting the application and rebooting the computer were frequent answers for both student and workplace users in previous research, but these were not common responses for the blind users in this study. Blind users tended to respond to these frustration situations differently than the visual users in previous research. The blind users were less likely to give up or to reboot the computer and were more likely to look for alternative solutions.

Parallels to how users in this study responded to the frustrating experiences can be seen in how users in this study reported that the frustrating experiences made them feel. Only in a few instances did the blind users in this study report feeling angry at themselves (19 instances), but they were far more likely to report that they were determined to fix the problem (81 instances).

5.3. Time Lost

One of the most surprising findings from this study was the amount of time lost due to these frustrating situations. In this study, participants reported losing, on average, 30.4% of time spent on the computer due to these frustrating situations. Although this is a pretty large amount of time, this is far less than the time lost reported by both the student and workplace users in previous studies. In the previous study of student users, the perceived amount of time lost was 38.9% (without the outliers). In the study of workplace users, the amount of time lost was 42.7% (without the outliers). The data collection methods used for the 100 blind participants, 50 workplace participants, and 111 student participants were the same. However, the study presented here only focused on Web usage, whereas the previous two studies included other computer usage; in the end, the computer usage in those studies was still primarily on the Web.

It is curious to note that the blind users, on average, wasted less time responding to frustrating situations than workplace or student users. One possible explanation for this is that blind users responded to frustrations differently than how visual users (both student and workplace) responded to frustrations. Blind participants in this study frequently reported that, when faced with a frustration, they found an alternative solution or figured out a way to fix it. This occurred much more frequently than with visual users in the previous studies. At the same time, visual users in the previous studies were much more likely to restart the program or reboot the computer than blind users in the study presented here. It is possible that the responses themselves—of looking for solutions or work-arounds rather than rebooting—could have saved the users time. When users reboot a computer, they lose time that could have been used in responding to a frustrating situation. All of these actions that are present in visual users but much less present in blind users—getting angry at themselves, giving up, rebooting—have an associated cost in time. Future examination of this data will need to also examine how and if these frustrations had any impact on the mood of the blind users and how that compared to visual users from the previous studies.

5.4. Implications for Web Designers and Webmasters

There are a number of potential enhancements that could be made by Web developers and Webmasters. It is clear that Web page design is still very frustrating for blind users. However, many of the improvements are easy to implement. Things such as clearer wording on forms, alt text, frame names, and links would go a long way to improving the user experience. Web designers could limit the use of plug-ins or, if plug-ins are used, ensure that both the plug-in application as well as the file being accessed through the plug-in were both accessible. Web designers and Webmasters should try and limit the use of features that override the user's normal browsing experience, such as breaking the Back button or having automatic page reloading. If Web designers experienced their Web pages in a linear format, as blind users do, this would give the designers a better sense of how to improve the various features on the Web so that they can be understood better when accessed through a screen reader. Because the solutions to most of the frustrations are not technically advanced, training and stronger government policy can help ensure that Web designers and Webmasters do consider the needs of blind users.

5.5. Implications for Screen Reader Designers

In general, participants that took part in this data collection did not report specific problems with screen readers that would lead to improved usability of the screen reader itself. However, participants did report problems with screen reader crashes and conflicts between the screen readers and software applications. More testing of screen reader applications needs to be done during development of new versions. First, this testing and improvement of screen readers needs to ensure that the screen reader crashes less frequently. Second, the screen reader needs to interface more effectively with various applications that are frequently used by blind users, especially Web browsers and plug-in applications. Blind users rely on screen readers as their primary computer output, so the importance of ensuring screen reader stability cannot be underestimated.

5.6. Implications for Users

From the data in this study, the implications for users are clear. You may not be able to control what occurs when you are on the Web, but you can control how you respond to the frustrating situation. The response that you choose will help or hurt your efforts. Try to remain calm, not blame yourself, and look for an alternative solution. Do not get angry at yourself; restart the program or reboot the computer (unless it crashes). We know from previous research that users tend not to use software documentation, so that is unlikely to change their habits and responses to frustration. However, additional training might help change the patterns of how users respond to frustrating situations. Previous research has found that in the Web environment, providing users with information about how the structure and inherent unpredictability of the Web does help them improve task performance (Lazar & Norcio, 2003).

6. SUMMARY

The idea of universal usability has come to the forefront only in the last few years, and in-depth studies of diverse user populations are now starting to be performed. The data from this study are fascinating. The typical expectation (stereotype) is that blind users, and users with various other impairments, take longer to perform tasks, especially computer tasks, than users without impairments. In this study, it was discovered that blind users waste a smaller percentage of time responding to frustrations than visual users. The key to understanding this is the approach to dealing with the frustrations. In this study, the blind users responded very differently to frustrations than the visual users in the previous study.

Another important finding is that many of the most common causes of frustration (e.g., unlabelled forms, inaccessible PDF files, missing or confusing alt text) are, from a technical point of view, easy to solve. If more attention is paid to these problems by Web developers and Web masters, the time spend by blind users responding to frustrations could be lowered even more. Some potential methods to improve this situation include better training, stronger government policy, and Web development tools that more strongly incorporate accessibility into the design process, right from the beginning.

REFERENCES

Birdi, K., & Zapf, D. (1997). Age differences in reactions to errors in computer-based work. *Behaviour and Information Technology, 16,* 309–319.

Carroll, J., & Carrithers, C. (1984). Blocking learner error states in a training-wheels system. *Human Factors, 26,* 377–389.

Ceaparu, I. (2003). Governmental Statistical Data on the Web: A Case Study of FedStats. *IT and Society, 1*(3), 1–17.

Ceaparu, I., Lazar, J., Bessiere, K., Robinson, J., & Shneiderman, B. (2004). Determining Causes and Severity of End-User Frustration. *International Journal of Human-Computer Interaction, 17,* 333–356.

Ceaparu, I., & Shneiderman, B. (2004). *Finding governmental statistical data on the Web: Three empirical studies of the FedStats topics page* (Journal of the American Society for Information Science and Technology Tech. Rep. No. HCIL-2003-31, CS-TR-4513, UMIACS-TR-2003-81). Available at http://www.cs.umd.edu/hcil

Czerwinski, M., Horvitz, E., & Wilhite, S. (2004). A diary study of task switching and interruptions. *Proceedings of the ACM Conference on Human Factors in Computing Systems,* 175–182.

Dormann, T., & Frese, M. (1994). Error training: Replication and the function of exploratory behavior. *International Journal of Human-Computer Interaction, 6,* 365–372.

Frese, M., Brodbeck, F., Heinbokel, T., Mooser, C., Schleiffenbaum, E., & Thiemann, P. (1991). Errors in training computer skills: On the positive function of errors. *Human–Computer Interaction, 6,* 77–93.

Ghaoiu, C., Mann, M., & Ng, E. (2001). Designing a humane multimedia interface for the visually impaired. *European Journal of Engineering Education, 26,* 139–149.

Hackett, S., Parmento, B., & Zeng, X. (2004). Accessibility of Internet Websites through time. *Proceedings of the ACM 2004 Conference on Assistive Technology,* 32–39.

Hazlett, R. (2003). Measurement of user frustration: A biologic approach. *Proceedings of the ACM Conference on Human Factors in Computing Systems,* 734–735.

Karshmer, A., & Gillian, D. (2005). Math readers for blind students: errors, frustrations, and the need for a better technique. *Proceedings of the 2005 International Conference on Human-Computer Interaction (HCII)* (CD-ROM).

Lazar, J. (2006). *Web usability: A user-centered design approach*. Boston: Addison-Wesley.

Lazar, J., Beere, P., Greenidge, K., & Nagappa, Y. (2003). Web accessibility in the Mid-Atlantic United States: A study of 50 Web sites. *Universal Access in the Information Society, 2,* 331–341.

Lazar, J., Dudley-Sponaugle, A., & Greenidge, K. (2004a). Improving Web accessibility: A study of Webmaster perceptions. *Computers in Human Behavior, 20,* 269–288.

Lazar, J., & Greenidge, K. (2006). One year older, but not necessarily wiser: An evaluation of Homepage accessibility problems over time. *Universal Access in the Information Society, 4,* 285–291.

Lazar, J., Jones, A., Hackley, M., & Shneiderman, B. (2006). Severity and impact of computer user frustration: A comparison of student and workplace users. *Interacting with Computers, 18,* 187–207.
Lazar, J., Jones, A., & Shneiderman, B. (2006). Workplace user frustration with computers: An exploratory investigation of the causes and severity. *Behaviour and Information Technology, 25,* 239–251.
Lazar, J., Meiselwitz, G., & Norcio, A. (2004). A taxonomy of novice user perception of error on the Web. *Universal Access in the Information Society, 3,* 202–208.
Lazar, J., & Norcio, A. (2003). Training novice users in developing strategies for responding to errors when browsing the Web. *International Journal of Human-Computer Interaction, 15,* 361–377.
Lazonder, A., & Meij, H. (1995). Error-information in tutorial documentation: Supporting users' errors to faciliate initial skill learning. *International Journal of Human-Computer Studies, 42,* 185–206.
Loiacono, E., & McCoy, S. (2004). Web site accessibility: an online sector analysis. *Information Technology and People, 17*(1), 87–101.
Murrell, A., & Sprinkle, J. (1993). The impact of negative attitudes towards computers on employees' satisfaction and commitment within a small company. *Computers in Human Behavior, 9*(1), 57–63.
Nielsen, J. (1994). *Usability engineering*. Boston: Academic Press.
Nordstrom, C., Wendland, D., & Williams, K. (1998). To err is human: An examination of the effectiveness of error management training. *Journal of Business and Psychology, 12,* 269–282.
Norman, D. (1983). Design rules based on analyses of human error. *Communications of the ACM, 26,* 254–258.
Norman, K. (2004). *Computer rage: Theory and practice*. University of Maryland.
Office of the New York State Attorney General. (2004). *Spitzer agreement to make web sites accessible to the blind and visually impaired*. Available at http://www.oag.state.ny.us/press/2004/aug/aug19a_04.html
Paciello, M. (2000). *Web accessibility for people with disabilities*. Lawrence, KS: CMP Books.
Riseberg, J., Klein, J., Fernandez, R., & Picard, R. (1998). Frustrating the user on purpose: Using biosignals in a pilot study to detect the user's emotional state. *Proceedings of the CHI 1998: ACM Conference on Human Factors in Computing Systems,* 227–228.
Robinson, J., & Godbey, G. (1997). *Time for life: The surprising ways Americans use their time*. University Park: Pennsylvania State University Press.
Rubin, J. (2001). Introduction to log analysis techniques. In C. McClure & J. Bertot (Eds.), *Evaluating networked information services: Techniques, policy, and issues* (pp. 197–212). Medford, NJ: Information Today.
Shneiderman, B. (1982). System message design: Guidelines and experimental results. In A. Badre & B. Shneiderman (Eds.), *Directions in human/computer interaction* (pp. 55–78). Norwood, NJ: Ablex.
Shneiderman, B. (2000). Universal usability: Pushing human–computer interaction research to empower every citizen. *Communications of the ACM, 43,* 84–91.
Slatin, J., & Rush, S. (2003). *Maximum accessibility*. New York: Addison-Wesley.
Sullivan, T., & Matson, R. (2000). Barriers to use: Usability and content accessibility on the Web's most popular sites. *Proceedings of the ACM Conference on Universal Usability,* 139–144.
Trewin, S., & Pain, H. (1999). Keyboard and mouse errors due to motor disabilities. *International Journal of Human-Computer Studies, 50,* 109–144.
Zajicek, M., Powell, C., & Reeves, C. (1998). A Web navigation tool for the blind. *Proceedings of the ACM Conference on Assistive Technology (ASSETS),* 204–206.
Zhao, H., Plaisant, C., Shneiderman, B., & Lazar, J. (2006). *A framework for auditory data exploration and evaluation with geo-referenced data sonification*. Manuscript under review.

APPENDIX A

Session Form

Please fill out this form for each frustrating experience that you encounter while using your computer during the reporting session. This should include both major problems such as computer or application crashes, and minor issues such as a program not responding the way that you need it to. Anything that frustrates you should be recorded.

1. What were you trying to do?
   Please type answer below

2. On a scale of 1 (not very important) to 9 (very important), how important was this task to you?
   Please type answer below

3. What program were you using when the problem occurred? If the problem was the computer system, please check the program that you were using when it occurred (Answer with all that apply).
   a. E-mail
   b. Chat or Instant Messaging
   c. Multimedia i.e. Audio Video
   d. Web Browsing
   e. Other Internet Use
   f. Adobe Acrobat
   g. Macromedia Flash
   h. Other (please explain)
   Please type answer below

4. Please write a brief description of the frustrating experience:
   Please type answer below
5. How did you ultimately solve this problem? (Please choose only one answer)
   a. I knew how to solve it because it has happened before
   b. I ignored the problem or found an alternative solution
   c. I figured out a way to fix it myself without help
   d. I was unable to solve it
   e. I asked someone for help (If chosen, please include number of people asked on separate line after your answer).
   f. I tried again
   g. I consulted online help or the system/application tutorial
   h. I restarted the program
   i. I consulted a manual or book
   j. I rebooted
   Please type answer below

6. Please provide a short step by step description of all the different things you tried in order to resolve this incident.
   Please type answer below

7. How often does this problem happen? (please answer only once)
   a. First time it happened
   b. One time a day
   c. More than once a day
   d. Once a week
   e. Several times a week
   f. Once a month
   g. Several times a month
   h. Several times a year
   Please type answer below

8. On a scale of 1 (*not very frustrating*) to 9 (*very frustrating*), how frustrating was this problem for you?
   Please type answer below

9. Of the following, how did you feel?
   a. Angry at the computer
   b. Angry at yourself
   c. Helpless or resigned
   d. Determined to fix it
   e. Neutral
   f. Other
   Please type answer below

10. How many minutes did it take you to fix this specific problem? (if this has happened before, please account only for the current time spent)
    Please type answer below

11. How much time was spent making up for lost work? (If this has happened before, please account only for the current time lost; e.g. time spent waiting or replacing lost work).
    Please type answer below

12. Until this problem was solved, were you able to work on something else? (Please explain)
    Please type answer below