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Determining Causes and Severity of End-User Frustration

Irina Ceaparu
Department of Computer Science, University of Maryland

Jonathan Lazar
Department of Computer and Information Sciences,
Center for Applied Information Technology, Towson University

Katie Bessiere
John Robinson
Department of Sociology, University of Maryland

Ben Shneiderman
Department of Computer Science, Human-Computer Ineraction Laboratory,
Institute for Advanced Computer Studies, &
Institute for Systems Research, University of Maryland

Although computers are beneficial to individuals and society, frequently users encounter frustrating experiences when using computers. This study represents an attempt to measure, in 111 participants, the frequency, the cause, and the level of severity of frustrating experiences. The data show that frustrating experiences happen on a frequent basis. The applications in which the frustrating experiences happened most frequently were Web browsing, e-mail, and word processing. The most-cited causes of frustrating experiences were error messages, dropped network connections, long download times, and hard-to-find features. The time lost due to frustrating experiences ranged from 47% to 53% of time spent on a computer, depending on the location and study method. After extreme cases were discarded, the time lost was still above 38%. These disturbing results should be a basis for future study.

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Requests for reprints should be sent to Ben Shneiderman, Department of Computer Science, University of Maryland, College Park, MD 20742. E-mail: ben@cs.umd.edu

1. INTRODUCTION

Computers have many beneficial impacts, but unfortunately, frustration is a universal experience for computer users. The annoyances of losing work when a crash occurs, struggling to understand an error message, or spending too much time to clear away spam and viruses have become symbolic of the struggles associated with modern technologies. Computers can be the cause of many problems, usually at the worst time possible.

Some problems stem from the users' lack of knowledge, poor training, or unwillingness to read instructions or take tutorials. Often frustration results from flaws in the computer hardware, software, or networking or troubling interactions among components supplied by diverse manufacturers or is the result of malicious actions by other users.

A number of preliminary research steps are necessary to guide developers who are working on the goal of making computer usage less frustrating for users. A first step is to gain a better understanding of what frustrates users of computers. Then taxonomies of frustrating experiences can be developed, and means to measure their severity and frequency can be identified. These three steps should lead to solutions with enough supporting evidence so that requests for improvements will be well received by all parties involved.

2. BACKGROUND RESEARCH

The literature on user frustration is just emerging. However, there are already a number of research directions related to errors, time delays, and emotional reactions to problematic situations.

2.1. Errors

Certainly, there is a lot of overlap in the areas of errors and frustration, as users do tend to find errors to be very frustrating. Frustration is a broader topic than errors. Errors are when users perceive that something is in an incorrect state, regardless of whether it is their fault, a design flaw, or an implementation bug (Lazar, Meiselwitz, & Norcio, 2003). Even if a computer is operating in a correct state and users perceive that the computer is operating in a correct state, there are many things that could cause users to be frustrated (such as pop-up advertisements, viruses, and spam mail). However, as errors are a major cause of user frustration, the research on errors can provide useful background literature for research on frustration.

Although there is no clear definition, it seems that an *error* could be broadly defined as when users perceive that something in the computing system is not providing the desired outcome and users are therefore unable to reach their task goals (Norman, 1983). This might be due to a hardware or software failure (such as a crash), which is not directly due to the actions of the users. Alternatively, an error might be caused by the actions of users. For example, users either choose the wrong

commands to reach their task goals, or they choose the correct commands but enter those commands in an incorrect manner (such as in the case of a spelling error or a mode error).

Errors can be especially frustrating experiences for novice users, who are unable to fully understand the cause of the error; are unable to understand how to appropriately respond to the error; and, therefore, may perform actions that compound the severity of the error (Carroll & Carrithers, 1984; Lazar & Norcio, 2000; Lazar et al., 2003). Even expert users may have trouble responding to errors if the system's feedback is poor. In addition, error messages tend to be inconsistent, unclear, and confusing, which does not help users respond to the error but is more likely to frustrate them (Lazar & Huang, 2003; Shneiderman, 1998).

2.2. Time Delays

Although users generally prefer a shorter response time, the appropriate response time is related to the users' past experiences, the users' knowledge level related to technology, the cost of an error, and outside time pressures. For instance, novice users may be willing to wait longer than expert users for a computer to respond (Shneiderman, 1998). In addition, the importance of the task and the related time pressure to complete a task may influence users' expectations and frustration related to time delays. Frustration can be reduced when delays are predictable and users are made aware of the estimated time until they can move on with their task. Recent research on time delays has focused on the Internet and Web environment. Time delays are especially frustrating on the Web, when users are typically requesting content from a remote site. In these situations, the delay can be caused by numerous factors and components (Sears & Jacko, 2000) and is inherently unpredictable (Johnson, 1995, 1998). It has been found in a number of studies that time delays are problematic on the Web. As the time delay increases, users may find the content less interesting (Ramsay, Barbesi, & Preece, 1998) and of a lower quality (Jacko, Sears, & Borella, 2000). A long time delay can make it harder for users to remember what they were doing and the related context in which they had made the request (Shubin & Meehan, 1997). In addition, Web pages that take a very long time to load may also cause users to believe that an error has occurred because the computer has not responded in an appropriate amount of time (Lazar, Meiselwitz, & Norcio, 2000, 2002).

2.3. Emotional Reactions

Another related area of research is that of emotional reactions to computing technology (Reeves & Nass, 1996). Schleifer and Amick conducted a study in which they analyzed the effects of computer system response time (slow vs. rapid) and method of pay (incentive vs. nonincentive) on mood disturbances and somatic discomfort (Schleifer & Amick, 1989). Regardless of method of pay, slow response time generated higher ratings of frustration and impatience than did rapid response time. In addition, ratings of rush and tension were higher with incentive

pay than without incentive pay, regardless of system response time. Mood disturbances and somatic discomfort increased linearly with the amount of time spent performing a data entry task over the course of the workday. This effect was independent of system response time or method of pay. The results indicate that computer systems that incorporate features such as rapid response times reduce work stress, whereas the motivational advantages of computer-based incentive pay programs must be balanced against the stress effects of this method of pay.

Another study had as a goal the development of a computer system trained to sense a user's emotional state via the recognition of physiological signals (Riseberg, Klein, Fernandez, & Picard, 1998). The researchers designed a controlled study in which participants took part in a vision-oriented computer game using a (seemingly) traditional graphical user interface. The game consisted of a series of puzzles. The researchers created incentives (a $100 prize) for the participants to play the game as fast as possible and achieve a good score. They also created seemingly random obstacles to attaining a good score in the game (they designed the software interface to simulate the mouse failing or "sticking" at specific but irregular intervals during game play), so that the participants would experience frustration. The study showed a correlation between psychological signal patterns (skin conductivity, blood volume pressure, and muscle tension) and game events. The method used proved efficient in solving some of the problems in building a computer that can recognize affect.

Other contributors to negative emotional responses are system complexity and poorly crafted interfaces, which lead to experiences of confusion, frustration, and failure (Baecker, Booth, Jovicic, McGrenere, & Moore, 2000). Such experiences may be most strongly felt by novice users, who often are confronted with instructions, menu choices, and dialog boxes that they cannot understand. One of the key challenges in making information and communications technologies universally usable is to bridge the gap between what users know and what they need to know, thereby leading to a more successful, less frustrating user experience.

2.4. User Satisfaction and Frustration

User satisfaction has been utilized in previous studies as a dependent variable, being used as an affective measure of the success of a technology (Collins, Caputi, Rawstorne, & Jayasuriya, 1999; Olaniran, 1996; Zviran, 1992). From the sociopsychological literature, satisfaction is also defined as the completion of a goal or task, and goal-directed behavior is aimed at the satisfaction of some need, desire, or want. Frustration occurs at an interruption or inhibition of the goal-attainment process, where a barrier or conflict is put in the path of an individual (Dollard, Doob, Miller, Mowrer, & Sears, 1939). Sigmund Freud defined frustration as both external and internal barriers to goal attainment and internal obstacles blocking satisfaction (Freud, 1958). In other words, people are frustrated if they are prevented from achieving expected satisfying results (Berkowitz, 1978). However, users can still achieve satisfaction in their tasks despite the presence of frustration in the path of task achievement. The technology acceptance model identifies useful-

ness and ease of use as the two biggest influences on user acceptance of technology (Davis, 1993). This model suggests that, even with a computer application that is not easy to use, users will persevere in their attempts to reach a task goal if it is important to them.

Compaq sponsored one large study of user frustration. A survey of 1,255 workers in the United Kingdom assessed their frustrations with information technology (Compaq, 2001). Of those who had their own personal computers at work, nearly half have felt frustrated or stressed by the amount of time it takes to solve problems. Two in 5 blamed computer jargon for exacerbating their frustration, and three fourths of respondents who experience daily problems with their computers said that their colleagues "swear at their monitors" out of frustration. The survey also analyzed the business cost of computer frustration. Nearly one fourth (23%) of respondents said that their work was interrupted daily due to computer crashes and other faults. Two in 5 who suffer daily breakdowns claimed that these delays caused them to miss deadlines, and 1 in 10 had felt like criticizing their company to clients as well as friends because of frustration with the ineptness of their information technology departments. This is despite the fact that 1 in 6 admitted that their problems are normally due to their own lack of knowledge and understanding.

Bugtoaster (http://www.bugtoaster.com) has made an important contribution to the collection and analysis of the source of frustrating experiences (application and system crashes). The Bugtoaster software consists of a client program installed on a computer and a Web site that work in concert to capture, track, and display information about the crashes that affect the computer. Normally, Bugtoaster sits silently on a user's system and waits for an application to crash. When it does, it captures the details related to the crash. The details of the crash are packaged up and stored on the user's computer hard disk. Periodically, crash details are sent to the Bugtoaster database server, where they are compared and correlated with the crashes of other Bugtoaster community members. Summaries of crashes can be viewed on the Web site along with large collections of statistical data regarding the top 50 applications that cause crashes, which operating systems and which vendors are involved in most crashes, and which bugs have been repaired.

3. RESEARCH METHODOLOGY

To learn more about what users find frustrating, we collected data about hundreds of experiences of frustration. First, a pilot study was conducted in a computer science class at the University of Maryland. Thirty-seven participants were asked to describe, in written form, frustrating experiences with computers. From an analysis of the data, a list of categories of problems and the frequency with which they appear was developed. The five categories were Internet problems, application problems, operating system problems, hardware problems, and other problems. Table 1 lists the top three frustrations for each of the five categories.

After the pilot study, a number of instruments were developed for use in the research study: a form for frustrating experience reports, a presession survey, and a postsession survey. The time diary method was adopted. Traditional time diaries

Table 1: Top Sources of Frustration From 37 Student Reports in Pilot Study

Internet	*Applications*	*Operating System*	*Hardware*	*Other*
Pop-up ads (7)	Windows "blue screen of death" (5)	Freezes (16)	Installation incompatibilities (4)	Spam (1)
Long download time (5)	"Illegal operation" error message in Windows Explorer (3)	Low memory (5)	Mouse problems (3)	Viruses (1)
Slow–dropped connection (3)	Excel problems (2)	Booting problems (3)	Printer problems (2)	File problems (locate, open) (1)

require users to keep a journal in which they log each activity and its duration throughout the day. The modified time diaries in this study required users to log each frustrating experience as it occurred during their session. This is an improvement over retrospective survey questions, because estimates from memory often lead to inflated or incorrect answers. In addition, modified time diaries enable researchers to capture with reasonable accuracy the session length and time lost due to frustrating experiences.

A key determinant of frustration is the importance of the users' goal. Research indicates that individuals are more committed to goals when the goals are important to them than when they are not (Locke, 1996). For this reason, users were asked to record their frustrations during a time when they would be using a computer for their personal use as opposed to tasks assigned to them.

Participants were asked to spend at least an hour using a computer and report their frustrating experiences via the frustrating experience reports (see Appendix A). No specific tasks were assigned or expected. Rather, users were simply asked to carry on with their normal tasks and report experiences that were frustrating. This approach to collecting data was more likely to result in data that were representative of the actual tasks that users would perform. A presession survey (filled out before beginning the session) and a postsession survey (filled out after the session) were also administered. Participants had to fill out a time sheet on the frustrating experience reports, recording the start time and the stop time of each session (one session in case they did not take any breaks) and the number of frustrating experiences per session.

The presession survey (see Appendix B) asked for demographic information, computer experience and attitudes, level of computer anxiety, and mood. Previous research indicates that level of computer experience or perception of computer self-efficacy can affect subsequent user behavior (Brosnan 1998; Murphy, Coover, & Owen 1989). The authors chose the questions for this study after reviewing previous research on the Computer Aptitude Scale, assessing computer attitudes, computer anxiety–confidence, and computer liking (Loyd & Gressard 1984; Nash & Moroz 1997). These studies suggested that prior experience and level of perceived knowledge would affect an individual's level of frustration as well. Therefore, the overall state of participants was assessed with three questions dealing with life satisfaction, general mood, and how often the individual gets upset.

The postsession survey (see Appendix C) consisted of five questions to assess mood after the session, how frustrated overall the individual was after the session, how these frustrations affected the rest of the day, and the frequency and typical nature of the frustrating experiences during the session. The pre- and postsession surveys were then tested with students and with a number of people in the human–computer interaction field to improve the clarity of questions.

Once the surveys and frustrating experience report had been developed on paper, they were implemented on the Web. A database-driven Web site on user frustration was developed at the Florida Institute of Technology (FIT) to collect the presession and postsession surveys, as well as the frustrating experience report. The Web is an accepted method for collecting surveys for research, and there are established ways to enhance the validity of data collected (Lazar & Preece, 2001).

The scenario for data collection included the following:

1. Users went to the FIT Web site, registered, and filled out the presession survey.
2. Users performed their typical tasks for an hour or more.
3. When users encountered a frustrating experience, they filled out a paper copy of the frustrating experience report. (Note that for users to fill out the frustrating experience report online at this time would have taken more time, and at the same time, the users would have been more distracted from the task at hand. It was felt that the procedure was more likely to model the task environment if the users were less distracted and were able to quickly fill out a paper form and continue with their tasks.)
4. After completing an hour or more of typical computer task work, users logged into the FIT Web site and filled out the postsession survey. After completing the postsession survey, users transferred their paper-based frustrating experience reports onto the Web-based database. This took place outside of the pre- or postsession surveys, as well as the hour-long session.

Two data collection phases were required: self-report diaries and observation of another user. These dual approaches were used to determine whether there were differences in results when users reported their own experiences versus when they were observing others. Self-reports might intrude in user work and lead to inflated estimates, whereas observations had the benefit of an external observer who might be more objective. Because participants at the University of Maryland (UMD) and Towson University (Towson) took part in both phases, researchers kept their data separate to see if these groups had different outcomes. Knowledgeable undergraduates at both institutions were available for participation as part of their courses in human–computer interaction and information technology.

3.1. Self-Report Phase

In the self-report phase, 33 computer science undergraduate students at the UMD and 26 computer information systems undergraduate students at Towson reported personal frustrating experiences. The participants were 37 men and 22 women,

with a mean age of 22.7 years (*SD* = 3.8). As discussed in the Research Methodology section, the participants had to go to the User Frustration Project Web site and register. They filled out a presession survey on demographic data and their experience with computers. Once the registration was completed, they were asked to report at least three frustrating experiences that took place when they were performing their common tasks. Then they had to log in to the Web site and answer a short postsession questionnaire intended to capture their mood after the frustrating experiences and fill out a form for each frustrating experience. Almost half of the users spent an hour or a little longer, but 31 users spent between 100 and 450 min documenting frustrating experiences.

3.2. Observation Phase

In the observation phase, the participants observed someone performing usual computer tasks and asked the person to fill out the presession survey, note any frustrations, and fill out the postsession survey. Essentially, the method for the observation phase was the same as the method for the self-reporting phase of the study. Observers had to ask the person they observed to go to the User Frustration Project Web site and register. The people observed had to fill out presession questionnaires regarding some demographic data and their experience with computers. Once the registration was completed, the participants had to sit beside the person observed and fill out (on paper) at least three frustrating experience reports. The participants were asked to encourage the persons being observed to think aloud and describe what they were trying to do and to ask questions if they were not sure whether the person was experiencing frustration. Think-out-loud studies are a common strategy in usability research and are believed to minimally impact user performance (Shneiderman, 1998). When observers were done with the observation, they had to ask the person observed to log in to the Web site and fill out a postsession questionnaire form intended to capture their mood after the frustrating experiences.

The participants were responsible for transferring the frustrating experience reports from paper to the online database. For this phase, the participants from UMD observed 31 participants, and the participants from Towson observed 21 participants. There were 21 male and 31 female participants, with a mean age of 26.1 years (*SD* = 13.1). Half of the users spent an hour or a little longer, but 26 users spent between 100 and 515 min documenting frustrating experiences.

4. RESULTS

Tables 2 and 3 contain data collected from the self-reports and observations in terms of problem source and solution taken. The analysis of data confirmed the first findings from the pilot study and helped better define the categories of problems, frequency with which they appear, cost they involve, and frustration they provoke.

Table 2: Problem Source for Self-Reports and Observations for University of Maryland (UMD) and Towson University

	Frequency of Problem Sources				
Problem Source	*Self–UMD N = 33, FE = 120*	*Observation–UMD N = 31, FE = 108*	*Self–Towson N = 26, FE = 79*	*Observation–Towson N = 21, FE = 66*	*Total*
Web browsing	34	32	31	25	122
E-mail	14	18	9	8	49
Operating system	14	11	1	4	30
Other internet use	12	4	6	4	26
Video/audio software	10	6	4	0	20
Word processing	5	20	10	10	45
Chat and instant messaging	7	6	5	1	19
File browsers	7	2	1	0	10
Programming tools	7	4	4	3	18
Spreadsheet programs	2	2	1	3	8
Graphic design programs	4	0	2	4	10
Presentation software	1	1	2	1	5
Database programs	2	0	2	0	4
Hardware	1	2	1	3	7

Note. *N* = number of subjects, FE = number of frustrating experiences.

Table 3: Solution Taken for Self-Reports and Observations for University of Maryland (UMD) and Towson University

	Frequency of Solutions				
Solution Taken	*Self–UMD N = 33, FE = 120*	*Observation–UMD N = 31, FE = 108*	*Self–Towson N = 26, FE = 79*	*Observation–Towson N = 21, FE = 66*	*Total*
I knew how to solve it because it happened before	44	36	11	11	102
I figured out a way to fix it myself	17	17	12	7	53
I was unable to solve it	16	18	16	10	60
I ignored the problem or found an alternative	16	8	9	9	42
I tried again	7	5	6	6	24
I restarted the program	3	4	3	4	14
I consulted online help	5	2	3	3	13
I asked someone for help	8	13	9	10	40
I rebooted	3	5	10	4	22
I consulted a manual or a book	1	0	0	2	3

Note. *N* = number of subjects; FE = number of frustrating experiences.

The five categories (Internet, applications, system, hardware, other) found in the pilot study appeared both in the self-reports and in the observation reports. However, subcategories that might be helpful in finding specific solutions to specific problems were defined (see Table 4).

The frequency chart (see Figure 1) indicates that most frustrating experiences had happened before, as frequently as several times a month, several times a week, or even several times a day.

Table 4: The Five Categories of Problems With Their Subcategories

Internet	*Applications*	*Operating System*	*Hardware*	*Other*
Timed out, dropped, or refused connections (32)	Error messages (35)	Crashes (16)	Installation–update incompatibilities (8)	Typing errors (4)
Long download time (23)	Freezes (24)	Response inconsistent with action (10)	Mouse problems (5)	Spam (1)
Web page–site not found (17)	Missing or hard to find features (23)	Slow response (8)	Printer problems (5)	
E-mail failures (not sent or received; attachments not opening; 15)	Crashes (13)	Unexpected message boxes (6)		
Pop-up ads (13)	Not opening or closing (13)	Low resources (4)		
	Response inconsistent with action (13)	Missing software (4)		
	Annoying features (12)	Unexpected or improper shutdowns (3)		
	Unexpected message boxes (6)	Virus problems (2)		
	Unrecognized file type (4)	Upgrading software (1)		
	Windows "blue screen of death" (3)	Insufficient help (1)		

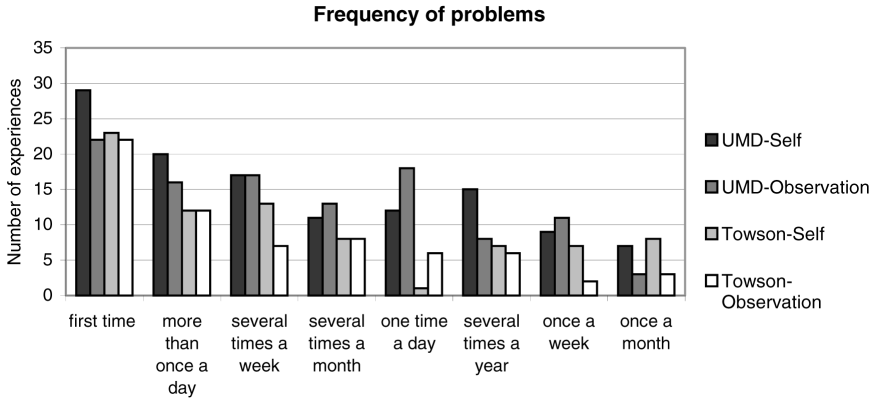

FIGURE 1 Frequency with which problems occurred for the four groups of participants studied. UMD = University of Maryland.

In terms of frustration, on a scale ranging from 1 (*least frustrating*) to 9 (*most frustrating*), the results collected for all the frustrating experiences reported show a high level of frustration (see Figure 2).

The cost of the frustrating experiences, measured in minutes lost, ranged from 0 to 1,537 min (Mean = 21, *SD* = 49—skewed because of the outliers; see Tables 5 and 6). Users' comments indicate that the minimum cost usually appeared in the situation in which a Web page had to be reloaded to display or in which users were not doing something important and just abandoned their tasks. The maximum cost usually appeared when users had to install–reinstall some software or clean the

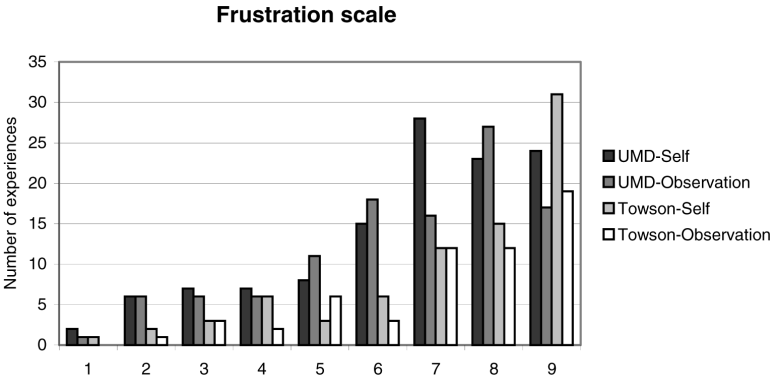

FIGURE 2 Level of frustration experienced by participants from four groups studied. UMD = University of Maryland.

Table 5: Total Minutes Lost, Number of Frustrating Experiences and Average Time Lost per Frustrating Experience Comparing University of Maryland (UMD) and Towson University

	UMD (9485 Usage Min; N = 64)			*Towson (7968 Usage Min; N = 47)*		
Problem Source	*Total Min. Lost*	*FE*	*Avg Min. Lost Per FE*	*Total Min. Lost*	*FE*	*Avg Min. Lost Per FE*
Operating system	877	25	35.1	353	5	70.6
E-mail	902	32	28.2	294	17	17.3
Web browsing	568	66	8.6	1,537	56	27.4
Other internet use	319	16	19.9	202	10	20.2
Word processing	280	25	11.2	281	20	14.1
File browsers	320	9	35.6	15	1	15.0
Video/audio software	356	16	22.2	200	4	50.0
Programming tools	126	11	11.4	134	7	19.1
Graphic design programs	215	4	53.7	101	6	16.8
Database programs	48	2	24	260	2	130.0
Chat and instant messaging	134	13	10.3	85	6	12.6
Presentation software	32	2	16.0	36	3	12.0
Hardware	30	3	10.0	70	4	17.5
Spreadsheet programs	44	4	11.0	108	4	27.0
Total	4251	228		3676	145	

Note. *N* = number of subjects, FE = number of frustrating experiences.

Table 6: Total Minutes Lost, Number of Frustrating Experiences and Average Time Lost per Frustrating Experience Comparing Self-Reports and Observations

	Self (10658 Usage Min; N = 59)			*Observations (6795 Usage Min; N = 52)*		
Problem Source	*Total Min. Lost*	*FE*	*Avg Min. Per FE*	*Total Min. Lost*	*FE*	*Avg Min. Per FE*
Operating system	613	15	40.9	617	15	41.1
E-mail	537	23	23.3	659	26	25.3
Web browsing	1408	65	21.7	697	57	12.2
Other internet use	384	18	21.3	137	8	17.1
Word processing	259	15	17.2	302	30	10.0
File browsers	320	8	40.0	15	2	7.5
Video/audio software	296	14	21.1	260	6	43.3
Programming tools	194	11	17.6	66	7	9.4
Graphic design programs	257	6	42.8	59	4	14.7
Database programs	308	4	77.0	0	0	0.0
Chat and instant messaging	122	12	10.2	97	7	13.8
Presentation software	13	3	4.3	55	2	27.5
Hardware	35	2	17.5	65	5	13.0
Spreadsheet programs	56	3	18.7	96	5	19.2
Total	4802	199		3125	174	

Note. *N* = number of subjects; FE = number of frustrating experiences.

computer of viruses. For installation only, users lost a total of 713 min (from which 300 min were from one user to install a new operating system). The majority of users reported costs of 3 to 30 min.

5. DISCUSSION OF THE RESULTS

The findings of this study can be discussed in three broad topic areas. These topic areas are causes of frustration, frequency of frustration, and time lost.

5.1. Causes of Frustration

The three task applications that were the cause of the most frustrating experiences were Web browsing (122 frustrating experiences), e-mail (49 frustrating experiences), and word processing (45 frustrating experiences). This by itself does not necessarily identify the greatest causes of frustration in general, nor does it identify these applications as the greatest offenders, but rather this reflects some of the most popular task applications for the users who participated in the study. It was felt that it was more powerful to let users perform tasks that were relevant and important to the users themselves rather than using preassigned tasks chosen by the researchers. With preassigned tasks, users might not correctly identify the level of true frustration, because the users might view the preassigned tasks as unimportant.

The specific causes of frustration may cross task applications and are important to look at for a discussion of possible solutions. The specific causes of frustration

most often cited (from Table 4) were error messages (35), timed out–dropped–refused connections (32), freezes (24), long download time (23), and missing/hard-to-find features (23). Some of these frustrating problems are challenging to solve (such as freezes and dropped connections). However, some of these frustrating problems are well documented, and the pathway to improvement is clear. Guidelines for clear, positive error messages appeared in the research literature as early as 1982 (Shneiderman, 1982). However, many computer applications continue to incorporate error messages that are poorly worded and confusing. Long download times can be improved by having Web designers write Web pages that are smaller and have fewer graphics and by having users upgrade their personal connection speeds to the Internet (Lazar, 2001). Improved interface design can assist in helping users find features that are not immediately obvious.

5.2. Frequency of Frustration

Frustration is a common event. The data indicate that frustrating experiences happen on a regular basis (see Figure 1). Most participants indicated that the frustrating experiences they encountered during the testing had occurred before (74.3% of frustrating experiences had occurred before), as frequently as several times a month (10.7%), several times a week (14.5%), or even several times a day (16.1%). This illuminates the fact that users must deal with frustrating experiences on a frequent basis.

In terms of how to respond to a frustrating experience, participants most frequently indicated that they "knew how to solve it because it happened before" (27.3%), they were "unable to solve it" (16.1%), or they "figured out a way to fix it myself" (14.2%). Participants reported (see Figure 2) that most of the frustrating experiences were highly frustrating (74% of the frustrating experiences were rated with 6–9 on the frustration scale). Furthermore, new types of frustrating experiences that have not previously occurred (and that users might not be able to respond to) can cause users to waste large amounts of time, if they can even complete their tasks. The amount of time wasted is discussed in the next section. The least commonly adopted solutions were as follows (see Table 3): The participant consulted a manual (3), the participant consulted online help (13), and the participant restarted the program (14). This supports the assertion that providing post hoc assistance by way of electronic or paper manuals is not a sufficient solution to the problem of user frustration.

5.3. Time Lost Due to Frustrating Experiences

One of the most surprising findings was that, in terms of minutes lost, one third to one half of the time spent in front of the computer was lost due to frustrating experiences. This assertion is true regardless of how the data were analyzed: comparing UMD and Towson participants or comparing self- and observation reports. The total time (in minutes) was defined as the total time in front of the computer (re-

corded by the participant in the modified time diary). Minutes lost were defined as follows:

Minutes lost = minutes spent to solve the problem
+ minutes spent to recover from any work loss due to the problem.

Figure 3 illustrates the findings in terms of minutes lost.

Pursuing the data in Table 5 in detail, we normalized the data for length of sessions, and it was found that the mean time lost per individual for UMD reports was 47.8% and for Towson reports was 53.1%. Similarly, we pursued the distinction between study methods in Table 6, and the analysis led to an average time lost of 50.1% from self-reports and 49.9% from observations. These differences suggest robustness of the results independent of location or study method.

Some applications caused a small number of problems, but the problem was significant in terms of minutes lost (e.g., databases, which caused only four frustrating experiences but with a mean of 77 min lost for each). Other applications, such as Web browsing, caused a large number of frustrating experiences, but each problem was less significant in terms of time lost. In some cases when there was a system crash, the participant reported as the problem source all applications that were open at the time of the crash. Another way of viewing the data is to examine the number of specific minutes lost per user, for each of the 111 users out of a total of 17,453 min of usage (see Figure 4).

Because there were a few outliers in the data, the top five outliers were examined individually. The user who reported the most minutes lost (633) was chatting online and the connection was dropped. The user reported 600 min lost, making the

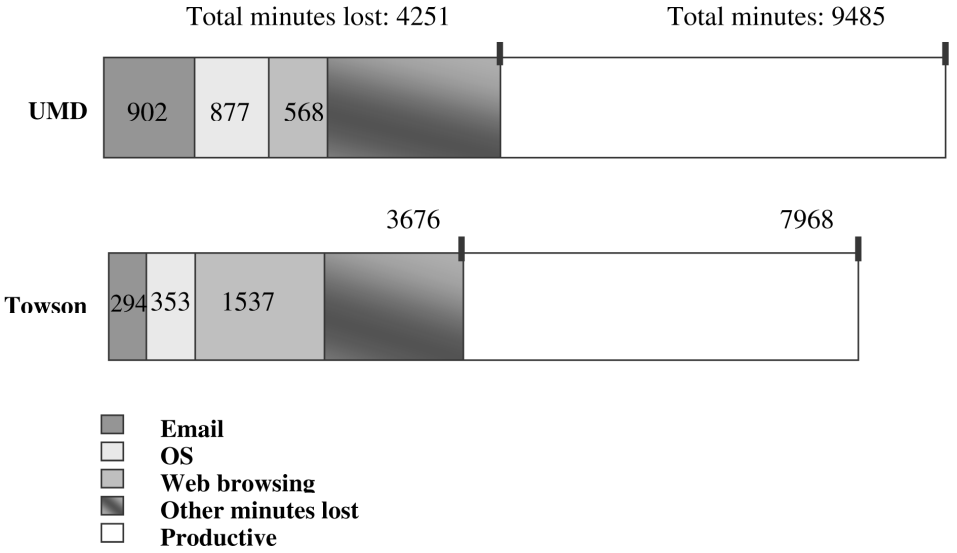

FIGURE 3 Minutes lost compared to total minutes of usage and top three time-consuming problems. UMD = University of Maryland; OS = operating system.

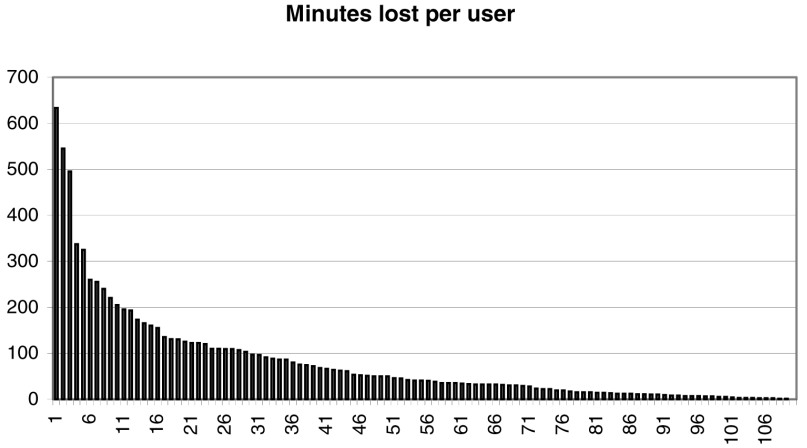

FIGURE 4 Minutes lost for each of the 111 users.

argument that the Internet provider "has changed from a static connection to a dynamic one and thus is a terrible ISP [Internet service provider] as a result," and therefore the user is accounting for all the time lost since the change. However, the user reported that the problem lasted just 20 min.

The second user in the top five users who reported extended lost time was attempting, as a first task, to boot up a Microsoft operating system, and, because each time the blue screen appeared, he spent 300 min installing Linux instead. The second task the user attempted was to defragment the hard drive. A message error appeared, and the user reported 200 min lost because of the inability to perform other tasks until the problem was fixed.

The third user was attempting to add multiple Internet providers to his Internet account. He got to the same error page four times. He reported 45 min for the time needed to fix the problem, and 300 min lost, because he could not do a class assignment. He also reported 1 hr lost because, while trying to download music off the Internet, the computer rebooted 10 times.

The fourth user reported 240 min lost while trying to get rid of a computer virus and another 60 min because the Internet was not working anymore and he had to wait for a friend to come and fix it.

Finally, the fifth user reported 240 min lost because, in trying to access a site that was important for one of the school assignments, he forgot the password, and the site had no retrieving password function, so he had to go home and look through his notes to find the password.

After discarding the five users with the highest lost times reported, the numbers for the minutes lost changed in the following way: For the UMD groups, the percentage of individual time lost dropped from 47.8% to 37.9%, and for the Towson groups, the percentage of time lost dropped from 53.1% to 43.5%. Likewise, for the self-reports, the percentage of individual time lost dropped from 50.1% to 38.9%, and for the observations, the percentage of time lost dropped from 49.9% to 41.9%.

A more conservative approach would be to count as minutes lost only the minutes spent to solve the problem that occurred, without including the minutes spent to recover work lost due to the problem. In this case, the number of minutes lost at UMD changed from 47.8% to 30.1% and the number of minutes lost at Towson changed from 53.1% to 26.2% (see Figure 5). Likewise, the number of minutes lost in the self-reports changed from 50.1% to 27.8% and the number of minutes lost in the observations changed from 49.9% to 29.2% (see Figure 6).

Regardless of how the data are viewed or analyzed, it is clear that a lot of time is lost by users who encounter frustrating experiences. This lost time has a value. Improved usability in information systems can be measured in time saved, and the value of that time can be quantified in monetary terms (Bias & Mayhew, 1994). Similarly, the substantial value of time lost due to frustrating experiences can be measured in monetary terms.

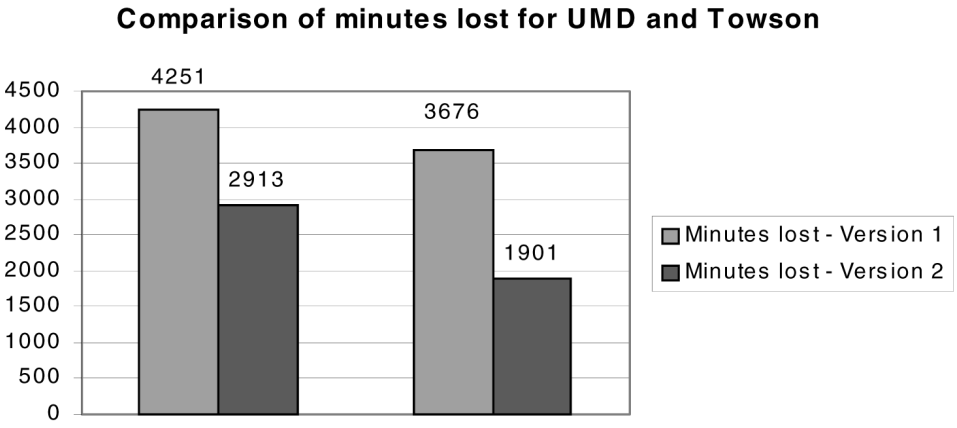

FIGURE 5 Minutes lost at the University of Maryland (UMD) and Towson University (Towson) including (Version 1) and excluding (Version 2) minutes spent to recover from work loss.

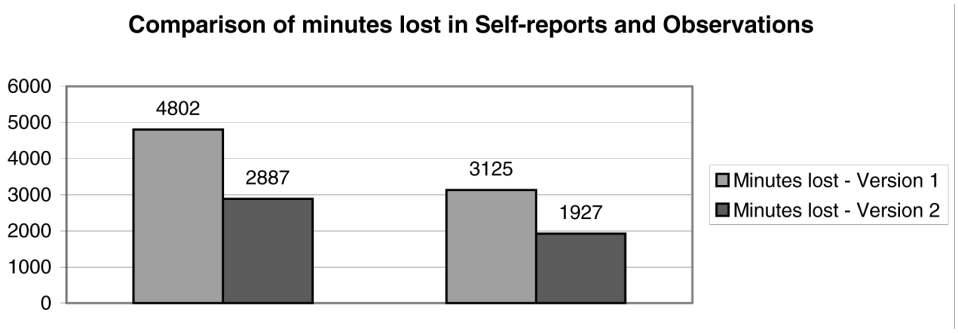

FIGURE 6 Minutes lost in self-reports and observations including (Version 1) and excluding (Version 2) minutes spent to recover from work loss.

6. CONCLUSIONS AND FUTURE WORK

Based on the data, it is clear that user frustration is a serious problem. The participants reported high levels of frustration as well as large quantities of wasted time. This wasted time comes at a cost in financial terms. In addition, increased levels of frustration can impact how users interact with other people during the day. The demographic and emotional responses in the pre- and postsession surveys are currently being analyzed (Bessiere, Ceaparu, Lazar, Robinson, & Shneiderman, 2002). These analyses will examine more of the sociopsychological issues in user frustration: For instance, is the level of user frustration tied to the level of self-efficacy and similar perceptions of users? How does a frustrating experience affect users' interactions with other people the rest of the day? Does computing experience affect frustration levels?

The data collected in this study answer some questions but raise others. Further studies are planned for the following purposes:

1. To examine frustration in workplaces: Are the frustrations of students different from those of professional users? How does the level of frustration relate to the perceived importance of the task?
2. To examine how different user populations react to frustrating experiences: For instance, will frustration levels be higher or lower with younger or older users? What about users with disabilities? It is well documented that younger users, older users, and users with disabilities have different needs and responses relating to errors, response time, and animation. As universal usability in information technology becomes a more widely accepted goal (Shneiderman, 2000), researchers must understand how to prevent or provide remedies for different user populations.
3. To develop metrics for measuring user frustration: It would be useful to measure frustrating experiences over time, to determine whether progress is being made by software developers, trainers, and users. It would also be helpful to measure the monetary costs of frustrating experiences.
4. To develop strategies for reducing the frequency of user frustration: More reliable software, superior user interfaces, clearer instructions, and improved training could help prevent problems.
5. To develop methods for coping with user frustration so that the time wasted is reduced: These include help desks, knowledge bases, online help, and social forms of help via e-mail, chat, instant messaging, or online communities.

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APPENDIX A: FRUSTRATING EXPERIENCE REPORT

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.

What were you trying to do?

On a scale of 1 (not very important) to 9 (very important), how important was this task to you?

Not very important	1	2	3	4	5	6	7	8	9	Very important

What software or program did the problem occur in? If the problem was the computer system, please check the program that you were using when it occurred (check all that apply).

__e-mail	__file browsers	__presentation software (e.g., Powerpoint)
__ chat and instant messaging	__spreadsheet programs (e.g., Excel)	__multimedia (audio/video software)
__Web browsing	__graphic design	__other _____
__other Internet use	__programming tools	

Please write a brief description of the experience:

How did you ultimately solve this problem? (please check only one)

__ I knew how to solve it because it has happened before
__ I figured out a way to fix it myself without help
__ I asked someone for help. Number of people asked ___
__ I consulted online help or the system/application tutorial
__ I ignored the problem or found an alternative solution
__ I was unable to solve it
__ I tried again
__ I restarted the program

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

How often does this problem happen? (please check only one)

___ more than once a day ___ one time a day ___ several times a week ___ once a week
___ several times a month ___ once a month ___ several times a year ___ first time it happened

On a scale of 1 (not very frustrating) to 9 (very frustrating), how frustrating was this problem for you?

Not very frustrating	1	2	3	4	5	6	7	8	9	Very frustrating

Of the following, did you feel:

___ angry at the computer ___ angry at yourself ___ helpless/resigned
___ determined to fix it ___neutral ___ other: _____

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) _____

Other than the amount of time it took you to fix the problem, how many minutes did you lose because of this problem? (if this has happened before, please account only for the current time lost, e.g., time spent waiting or replacing lost work). _____

Please explain:

Until this problem was solved, were you able to work on something else?
____Yes ____No
Please explain:

APPENDIX B: PRESESSION SURVEY

E-mail: _____

Section 1: Demographic Information

1. Age:
2. Gender: __Female __Male
3. Education: __High School Graduate
__Freshman/Sophomore in College
__Junior/Senior in College
__College Graduate
__Advanced Degree
4. Employment: __Student
__Professional/Managerial
__Technical
__Administrative
__Other

Section 2: Computer Experience and Attitudes

1. How many years have you been using a desktop or laptop computer for home or work use?
2. How many hours per week do you use a desktop or laptop computer?
3. What type of Operating System is installed on the computer that you are currently using?

DOS	Windows NT
MacOS	Windows ME
Unix/Linux	Windows 2000
Windows 95	Windows XP

4. What type of applications and programs do you typically use? (check all that apply)

__E-mail
__Web Browsing
__Chat and Instant Messaging
__Other Internet Use
__Spreadsheet Programs (Excel)
__Other Multimedia (audio/video software)
__Graphic Design Programs
__Word Processing
__Programming Tools
__Presentation Tools (PowerPoint)
__Database Management/Searching

5. How many years have you been using the Internet?
6. How many hours per week do you spend online? Please indicate the amount of time that you are actually using the computer while online, not simply the amount of time you are connected to the Internet.
7. At work, do you have
__a permanent connection to the Internet
__dial-in through a modem
8. Which of the following do you do when encountering a problem on the computer or in the application that you are using?

__Try to fix it on my own
__Ask a friend/relative for help
__Consult a manual or help tutorial
__Ask Help Desk or a Consultant for help
__Give up or leave it unsolved

9. How sufficient is your computer software and/or hardware for the work that you need to do?

Not at all	1	2	3	4	5	6	7	8	9	Very

Section 3: For the following questions, please choose the number that best corresponds to your feelings

1. Computers make me feel:

Very Uncomfortable	1	2	3	4	5	6	7	8	9	Very Comfortable

2. When you run into a problem on the computer or an application you are using, do you feel:

Anxious	1	2	3	4	5	6	7	8	9	Relaxed/ Indifferent

3. When you encounter a problem on the computer or an application you are using, how do you feel about your ability to fix it?

Helpless	1	2	3	4	5	6	7	8	9	Confident that I can fix it

4. How experienced do you think you are when it comes to using a computer?

Very Inexperienced	1	2	3	4	5	6	7	8	9	Very Experienced

5. When there is a problem with a computer that I can't immediately solve, I would stick with it until I have the answer.

Strongly Disagree	1	2	3	4	5	6	7	8	9	Strongly Agree

6. If a problem is left unresolved on a computer, I would continue to think about it afterward.

Strongly Disagree	1	2	3	4	5	6	7	8	9	Strongly Agree

7. Right now, how satisfied with your life are you?

Very Unsatisfied	1	2	3	4	5	6	7	8	9	Very Satisfied

8. How often do you get upset over things?

Not Very Often	1	2	3	4	5	6	7	8	9	Very Satisfied

9. Right now, my mood is:

Very Unhappy	1	2	3	4	5	6	7	8	9	Very Happy

APPENDIX C: POSTSESSION SURVEY

For the following questions, please choose the number that best corresponds to your feelings.

1. Right now, my mood is:

Very Unhappy	1	2	3	4	5	6	7	8	9	Very Happy

2. We asked you to record your frustrating experiences. Overall, how frustrated are you after these experiences?

Not Frustrated at All	1	2	3	4	5	6	7	8	9	Very Frustrated

3. How will the frustrations that you experienced affect the rest of your day?

Not at All	1	2	3	4	5	6	7	8	9	Very Much

4. Are the incidents that occurred while you were recording your experiences typical of your everyday computer experience?

Yes No

5. In general, do you experience more or less frustrating incidents while using a computer on an average day?

Less	1	2	3	4	5	6	7	8	9	More

6. Did these frustrating experiences impact your ability to get your work done?

No impact	1	2	3	4	5	6	7	8	9	Severe impact

7. Did these frustrating experiences impact your interaction with your coworkers?

No impact	1	2	3	4	5	6	7	8	9	Severe impact

Please enter in the time increments that you used in your self-reporting sessions. This information is important in order to determine how many incidents occurred in each session, so please be as accurate as possible.

Start Time: _____	Stop Time: _____	Number of Incidents: _____
Start Time: _____	Stop Time: _____	Number of Incidents: _____
Start Time: _____	Stop Time: _____	Number of Incidents: _____
Start Time: _____	Stop Time: _____	Number of Incidents: _____