Design And Evaluation Of An Internet Study Tool As A Data Collection Device

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Abstract

This paper describes the design, capabilities, strengths and weaknesses of a tool that collects data from subjects through the Internet. The Internet tool was designed for students studying cardinalities, a difficult data modeling topic frequently taught in the accounting information systems course. The Internet tool was able to observe usage and task accomplishments of subjects. We used these observations to learn characteristics about tool usage and to compare computer-recorded and self-reported data. These comparisons allow us to evaluate the Internet tool as a data collection device.

Introduction

Research is a piecemeal discovery process, testing the same phenomena under different conditions. Technological innovations have often helped researchers study phenomena from new perspectives (Hunton and McEwen 1997). In this paper, we look at the Internet as a data collection device that allows us to observe a subject's behaviors in unprecedented ways.

The Internet is reshaping many of our basic activities such as economic transactions (e-commerce), education (distance learning) and research. The Internet has revolutionized knowledge dissemination (Detmer and Shortliffe 1997) and it has brought vast new opportunities for knowledge discovery. One example of knowledge discovery is data collection. Examples of successful use of the Internet as a data collection device include electronic surveys (Pitkow and Recker 1995, Schmidt 1997), content analysis of Internet-mediated communication (Beals 1992), and web usage analysis (Bertot et. al. 1997, Stout 1997). In this paper, we present a research study that uses the Internet to observe subjects performing a task. To accomplish our research objectives, we implemented an interactive learning tool on cardinalities to be used by students. Cardinalities are a difficult data modeling concept often taught in the accounting information systems course (Hollander et al. 2000, Romney and Steinbart 2000). Our setting allowed us to investigate three interesting facets regarding data collection through the Internet: task related usage of the Internet, observation of subjects' behavior in the task environment and comparison of computer-recorded versus self-reported data.

The paper is organized as follows. The first section describes background research on strengths and weaknesses of automated data collection and studies that compare self-reported and computer-recorded data. The next section describes the study that was conducted including design of the tool and difficulties overcome from an earlier version of the tool. The final section discusses data that was collected and conclusions reached. We found that students do not estimate their time of use on the tool very precisely, but that the time reported is not biased in any particular direction. We also found that students overstate the amount of work performed and their actual performance. The final section highlights conclusions, limitations and opportunities for future research.

Background

In behavioral research, data is collected from subjects in many formats including direct observation, surveys, and computerized collection. Advantages of computerized data collection include automation of the collection process reducing the researcher's work and unobtrusive collection of accurate data reducing response bias and de

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mand characteristics (Rice and Borgman 1983). At the same time Rice and Borgman (1983) point out some of the disadvantages of computerized data collection including extensive data management, ethics and privacy, and lack of control over subjects. These issues continue today and will be addressed in relation to the study in this paper.

A number of studies have examined automated data collection and the relationship between self-reported and computer-recorded data. These studies often compare self-reported system usage with recorded usage because acceptance of a new system is often measured by self-reported use of the system. Ettema (1985) compared frequency and duration of system use with self-reported data and found that the two information types were not consistent with each other and produced different results in regression analysis. Straub, Limayem and Karahanna-Evaristo (1995) also found that computer-recorded and self-reported usage measures are not strongly related to one another. Collopy (1996) found that those with light system usage tended to overestimate time spent on the computer, while those with heavier system usage tended to underestimate time spent on the computer.

Collopy (1996) also notes that groups as a whole adjust responses in a socially acceptable direction. This is a response bias and varies based on the situation. In other examples, Pentland (1989) found that respondents tended to overestimate the time spent on laptop computers and Hartley et al. (1977) found that workers tend to overestimate the time spent on certain work tasks in a socially acceptable direction.

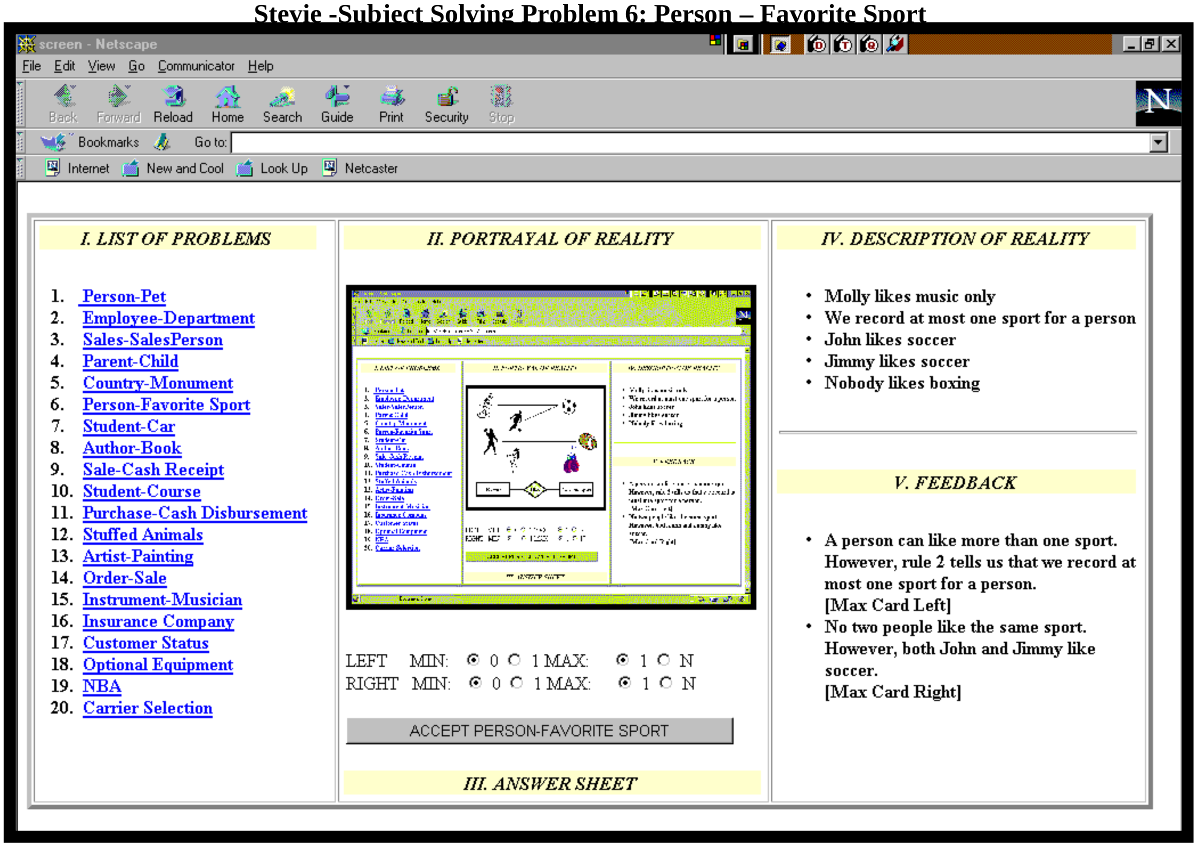
These studies that examine responses in socially motivated situations have implications for this current study. The three pieces of information that we collect both by questionnaire and automatically through the Internet are length of use, number of problems attempted and number of problems correct on the first try. Since this task is performed in an educational setting and the completed questionnaire is returned to the instructor, we expect that students will report in the socially acceptable direction. That is, we expect responses that overestimate their performance even though they are aware that they are part of an experiment, are being monitored and agreed to participate in the study.

Study Tool

An interactive learning tool, called Stevie, was designed for students learning cardinalities, a difficult topic in data modeling often taught in the accounting information systems course. Stevie was constructed for two purposes: (1) to help students learn cardinalities and (2) to observe the use of the tool and to compare computer-collected to self-reported data. Access to Stevie required a valid username and password. We assigned these user names and passwords approximately one to two weeks before the exam on data modeling and told students they could use the tool for extra practice. During the term in which we were conducting the study, students signed a form stating that they knew they were being monitored and that their identity would be kept confidential.

Stevie consists of twenty data modeling problems as shown in the left column of Figure 1. Each problem contains a graphical and verbal description of a relationship between two entities. These descriptions are shown in Parts II and IV of Figure 1. Students need to use these descriptions to determine the cardinalities for the relationship. For each problem selected, there are two choices for each of four cardinalities on the answer sheet in Part III of the screen. Therefore, there are a possible of sixteen responses to each problem. Students choose a cardinality problem to solve by clicking on one of the twenty problems and give their answer for each of the four cardinalities. The computer tells them if they are right or wrong. If any of the four cardinalities is incorrect, the computer tells them what their model of the relationship would mean so that they can better understand why their answer is incorrect. Then, the student has the opportunity to try again. Students can try as many of the problems as they wish and can try each of the problems as many times as they wish. For further discussion of Stevie as a study tool, see Geerts and Waddington (2000).

Figure 1
Stevie -Subject Solving Problem 6: Person – Favorite Sport



So then, how does this tool work technically? We used Cold Fusion, a middleware product, for the implementation of Stevie. Cold Fusion allows the seamless integration of database technology into Web applications without the use of an advanced programming language such as C++ or scripting language such as Perl. We used an HTML form to implement the answer sheet. When a student submits an answer, a Cold Fusion template with the user ID, the problem number and the four cardinality values attached is activated by the Cold Fusion engine. The backend database includes an advice table that is used to dynamically generate the feedback message.

The answer sheet Form is also used to record observations of the interaction between the student and Stevie. When a student submits an answer for evaluation, a combination of CGI variables and application-specific data is stored into the answer table. Each answer is assigned a unique number (ID). UserID uniquely identifies the subject. UserID, username and password are stored in the user table. DateEntered (date and time) and Client Browser are examples of CGI variables that are included in the observational descriptions. These data items allow us to analyze when students use the tool, the pace they use to solve problems, and the type of browser used. The remaining data items collect the answers given by the student. These application-specific data allow us to analyze if students select problems at random or solve them sequentially. It also allows us to evaluate the types of problems that cause students difficulties.

Figure 2 shows observations for one subject that used Stevie. The data gathered combines data collected through CGI variables such as date and browser with task-related data such as problem number and cardinality values submitted by the subject. From the observations in the table, we learn that this subject used Stevie once. He or she logged on just before midnight on 3/1/98. He or she used the tool for just under an hour, worked on average 130 seconds on each problem, tried all twenty problems, had 13 problems correct on the first attempt and it never took more than two attempts to solve any problem. The data gathered are useful for a better understanding of the student learning process.

Automatically collecting all this data in a backend database has many advantages over collecting data piecemeal such as on disk or by e-mail. As noted previously, one of the main concerns with computer-collected data is data management. When data is collected by disk or e-mail, the data needs to be consolidated in a manageable fashion. Data collected automatically using a backend database can be analyzed directly using queries or it can be easily downloaded into a statistics package. Using the Internet also has several accessibility advantages over other computer-recording devices. First, use of the Internet is free through universities, so cost savings can be achieved. Also, use of the Internet makes location of the subject anywhere in the world irrelevant.

Using the Internet, however, does have some difficulties. First, to collect the data automatically as done in this study takes some programming expertise. Also, while the tool as designed now meets our objectives, an earlier version of the tool turned out to be problematic. A prototype of the tool used a scripting language called JavaScript for implementation and data was collected through e-mail. This was a simple solution that did not involve a backend database or complex programming. However, some students had browser compatibility problems, some decided to turn off the e-mail submission to the researcher and some with Internet experience figured out how to look up the answers. The prototype could not work for the data collection in this study. The subjects may not be able to submit data, the data may be altered or the subject may decide not to submit the data. This is what Rice and Borgman (1983) meant when they said that you are not always sure what data you are getting when you automatically record data. For the new version of the tool, we were careful to fix the problems encountered to make sure the data would be accurate and usable. The final version of the tool, as described above, solves the three problems reported.

Results

The tool was made available to over 300 students at three universities, two in the Midwest and one in the Southeast. We had 253 valid subjects who signed a consent form, received valid usernames and completed a post review questionnaire. Of these subjects, 104 chose to use the tool for extra practice in studying for the exam. We collected two different types of data: observational data through the Internet application and demographic and self-reported data by means of a post-review questionnaire (Figure 3).

The two different types of information collected help to study the individuals using the tool. One interesting observation emerged from the analysis of demographic information. It is generally assumed that Internet users are, at least for now, a non-representative subject pool of primarily young males (Shade 1998 and Comber et al. 1997). However, we found that for this Internet tool, there was no significant difference between the sexes. Of the 253 valid subjects, 137 or 54.2% were male and 116 or 45.8% were female. Of the 104 users of Stevie, 51 were male and 54 were female. Therefore, the population of subjects had a higher male concentration, but the users had a higher female concentration. The difference is not significant using a Chi Square test.

Other interesting information was collected directly by the tool. An analysis of browsers used indicated that the 104 subjects used 46 different versions of browsers. This observation makes it clear that compatibility with different browsers is a must when the Internet is used for data collection. Figure 4 compares users logged in from home with users logged in elsewhere, primarily from school. As can be noted from the figure, the tool was used at all different times of the day. One observation is that the most common use of Stevie was from home in the late evening, between 9:30 and 11:30 p.m. It should be noted that the number of subjects in the study and the number of users in Figure 4 do not compare because subjects could use the tool more than once and for more than an hour at a time.

Figure 2. Observation for Subject with UserID 294

ID	UserID	DateEntered	ClientBrowser	No	carda	cardb	cardc	cardd

ID	=	Answer from a Subject
UserID	=	Subject identification
DateEntered	=	Date and time when answer was submitted
ClientBrowser	=	Browser used by Client – Computer used by Subject
No	=	Identification Number Problem (1 – 20)
Carda	=	Left Minimum Cardinality
Cardb	=	Left Maximum Cardinality
Cardc	=	Right Minimum Cardinality
Cardd	=	Right Maximum Cardinality

ID	UserID	DateEntered	ClientBrowser	No	carda	cardb	cardc	cardd
4698	294	3/1/98 11:58:21 PM	Mozilla/4.0					
4699	294	3/2/98 12:02:58 AM	Mozilla/4.0	1	0	n	1	1
4700	294	3/2/98 12:05:13 AM	Mozilla/4.0	2	0	1	1	n
4701	294	3/2/98 12:07:50 AM	Mozilla/4.0	3	0	n	1	1
4702	294	3/2/98 12:13:20 AM	Mozilla/4.0	4	1	n	1	1
4703	294	3/2/98 12:14:03 AM	Mozilla/4.0	4	1	n	1	n
4704	294	3/2/98 12:15:31 AM	Mozilla/4.0	5	1	n	1	1
4705	294	3/2/98 12:17:12 AM	Mozilla/4.0	6	1	1	0	n
4706	294	3/2/98 12:17:51 AM	Mozilla/4.0	6	0	1	0	n
4707	294	3/2/98 12:19:20 AM	Mozilla/4.0	7	0	1	1	1
4708	294	3/2/98 12:20:41 AM	Mozilla/4.0	8	1	n	1	n
4709	294	3/2/98 12:23:01 AM	Mozilla/4.0	9	1	1	0	1
4710	294	3/2/98 12:24:01 AM	Mozilla/4.0	9	0	1	0	1
4711	294	3/2/98 12:25:44 AM	Mozilla/4.0	10	1	n	0	n
4712	294	3/2/98 12:28:58 AM	Mozilla/4.0	11	0	1	0	1
4713	294	3/2/98 12:29:43 AM	Mozilla/4.0	11	0	1	0	n
4714	294	3/2/98 12:31:54 AM	Mozilla/4.0	12	0	n	0	n
4715	294	3/2/98 12:33:13 AM	Mozilla/4.0	13	1	1	1	1
4716	294	3/2/98 12:36:58 AM	Mozilla/4.0	14	0	1	1	1
4717	294	3/2/98 12:38:47 AM	Mozilla/4.0	15	0	n	1	n
4718	294	3/2/98 12:42:53 AM	Mozilla/4.0	16	0	1	0	n
4719	294	3/2/98 12:44:57 AM	Mozilla/4.0	16	0	n	0	1
4720	294	3/2/98 12:48:47 AM	Mozilla/4.0	17	1	1	0	n
4721	294	3/2/98 12:50:58 AM	Mozilla/4.0	18	0	n	1	n
4722	294	3/2/98 12:52:33 AM	Mozilla/4.0	19	1	n	1	n
4723	294	3/2/98 12:53:25 AM	Mozilla/4.0	19	0	n	0	n
4724	294	3/2/98 12:55:49 AM	Mozilla/4.0	20	0	n	1	n
4725	294	3/2/98 12:56:51 AM	Mozilla/4.0	20	1	n	1	n

Figure 3
Questionnaire

Please answer the following questions. If you used Stevie, please answer Parts I and II. If you did not use Stevie, please answer Part I only. Remember, your answers to these questions are confidential and will not be used for evaluating your performance.

Part 1:

1. Name: ____
2. Age: __________
3. Gender: *M* *F*
4. Overall GPA: __________
5. How would you describe your previous experience using the Internet ?
   None *Low* *Average* *High*
6. How would you describe your cardinality experience before this class?
   None *Low* *Average* *High*
7. How would you describe your computer skills in general before entering this class?
   None *Low* *Average* *High*
8. Approximately how long did you study for Exam 1 ? ____________
   Which of the following did you use to study for Exam 1 ?
   (list the approximate amount of time for each.)
   Instructor office hours ___________
   Stevie ___________
   Notes/Text ___________
   Classmate ___________
   No Studying ___________
   Other ____________ ___________

Please answer question 9 if you DID NOT USE STEVIE. IF YOU USED STEVIE, go to Part 2.

9. If you did not use Stevie, please circle the explanation that best describes why you chose not to use it. If none of the descriptions are applicable, give a brief description in the Other category.
   I felt adequately prepared for the cardinalities portion of the exam without it.
   I did not have time to use it.
   I tried to use it, but could not get it to work.
   I do not feel comfortable using computer study tools.
   I did not have access to a computer while studying for the exam.
   I heard from other students that it wasn't very useful.
   I did not think it would be useful.
   Other: _____________

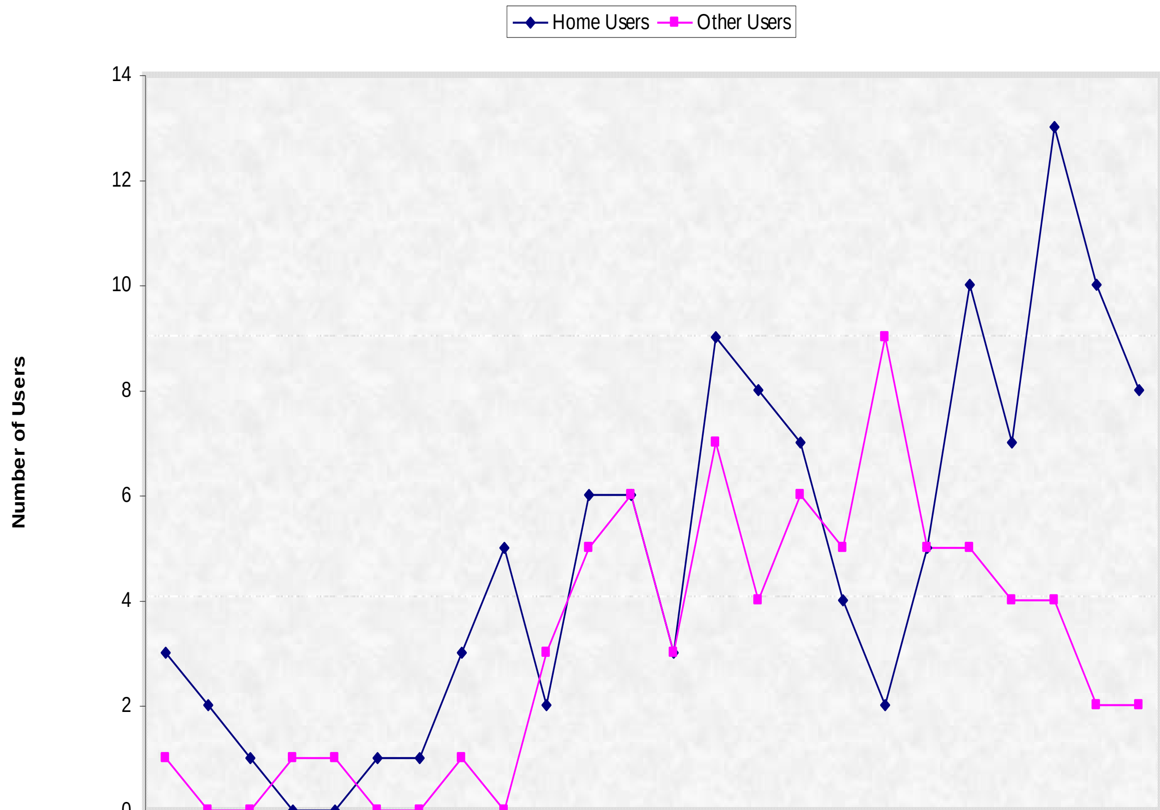
Part 2: Please answer these questions only if you used Stevie.

1. How many different times did you use Stevie? _____
2. How long did you spend logged-on using Stevie (not including time you spent reading the directions, etc. before you logged-on)? _____
3. Stevie has 20 patterns. How many patterns did you try?
   1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
4. How many patterns did you get correct on the first try?
   1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
5. Where were you when you tried Stevie? List more than one location if applicable.
   Home/Dorm
   School

Other _______________

6. Approximately when did you use *Stevie? (List more than one time if applicable).*
   Date: __________ Time: ________________
7. Which browser did you use to access Stevie (Netscape, Microsoft Explorer, etc.) ?
   ____
8. How helpful did you find Stevie for preparing you for Exam 1?
   Not helpful *Somewhat helpful* *Moderately helpful* *Very Helpful*
9. Would you recommend Stevie to other students who are studying cardinalities?
   Yes *No*
10. Do you have any suggestions to improve Stevie?

Figure 4
Stevie – Usage/Time of Day



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Home Users	3	2	1	0	0	1	1	3	5	2	6	6	3	9	8	7	4	2	5	10	7	13	10	8
Other Users	1	0	0	1	1	0	0	1	0	3	5	6	3	7	4	6	5	9	5	5	4	4	2	2

Hour

We compared computer-recorded and self-reported data to evaluate our Internet tool for data collection purposes. There were three such comparison variables in the study: the amount of time the tool was used, the number of problems attempted and the number of problems correct on the first try. As discussed earlier, since working hard in school is socially desirable, we expect students to overstate their performance on all three of these variables.

The results for the 104 students that used the tool are as follows. For the time spent variable, the estimated time spent and the actual time logged on the tool was, on average, almost equal. The average estimated time was 35.8 minutes and the average actual time was 34.6 minutes. Just by looking at the averages, it appears that students are good at estimating time spent. The standard deviation, however, is 23.8, indicating that their estimates of time were scattered but not biased in one particular direction.

The next variable measured by both the computer and questionnaire was how many problems were attempted. There was a maximum of twenty problems, so there is a ceiling effect here. Students cannot estimate over twenty. Despite this, on average, students said they attempted 17.2 problems when they actually attempted an average of 16.3 problems, approximately one less. This difference is significant at $p < .05$ using a t test.

The final variable compared was the number of problems correct on the first try. This variable does not have the ceiling effect that the last one did because only one student scored all twenty problems correct on the first try. Students reported that they scored an average of 13.2 problems correct on the first try when in fact they only scored an average of 10.8 correct on the first try. This difference is significant at $p < .01$ using a t test. It is also interesting to note that not one of the students underestimated the number they scored correct on the first try.

The correlations between the computer-recorded and self-reported information were also conducted for these three variables. For the time variable, the computer-recorded and self-reported numbers are correlated at .23, making it appear that students could not remember how long they spent on the tool. The other two correlations were much higher, both at .80. It appears, however, that they were highly correlated yet biased in the direction of overstatement of both problems attempted and problems correct on the first try.

Conclusions and Limitations

The goal of this study was to introduce a relatively new way of collecting data: through the Internet. A tool was designed to capture information automatically such as user identification, time, browser and information related to the task. Advantages of data collected through the Internet using middleware and a backend database include data collection in a ready to use format, cost savings and ease of subject availability. Some of the disadvantages of this technique include knowledge of Internet programming skills and lack of control over subjects.

The study shows some characteristics of use of the Internet study tool and compared computer-recorded and self-reported data. We found that both males and females used the tool similarly, students used many different browsers and students worked at all different times of the day. We found that students are not very good at estimating time spent on the tool, but the estimates were not biased. We also found that students significantly overestimate the number of problems attempted and the number of problems correct on the first try. These findings support the notion that subjects report in a socially desirable direction. That is, that they reported that they worked harder and more accurately than they actually did. These results, consistent with previous studies, warn of the danger associated with using self-reported data.

Lack of control over subjects is a limitation of this study even though subjects are monitored through the Internet. There is the potential of outcomes being influenced by uncontrollable factors. For this study, examples of such extraneous events include interruptions or people working in a group. With interruptions, time recorded as being spent on a problem would be overstated. With groups, the work of several students would be recorded as the work of one individual. This lack of control is common in quasi-experimental designs. Quasi-experimental design is often considered as a trade-off between a better study of real-world processes and a loss of rigorous controls and is a threat for internal validity (Ray 1997).

Suggestions for Future Research

In future studies, subjects could be placed in different treatments using the technology described in this paper. Morrow and McKee (1998) discuss an example of a between subjects Web experiment where subjects are exposed to different treatments. They use if-else logic in CGI scripts to assign subjects to treatments. Cold Fusion, the software used in this study, could also be used with conditional processing tags for similar designs with less programming requirements. The first subject that logs in would see the first treatment, while the second student that logs in would see the second treatment, etc. This conditional processing allows control over random assignment of subjects to conditions and could be useful for many accounting researchers. 🕮

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Notes