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Viewing the Learning Process: Assessment Via Usability Testing

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Abstract

Learning through computer-based activities provides a multi-modal approach in which the user can select the educational media and process. Effective development of these activities requires an understanding of user interactivity. Traditional assessment, such as test scores and subjective surveys, looks at end results and attitudes. This method does not monitor the learning process. In particular developer needs to accommodate diverse usage preferences and choices. Hence, assessment should involve usability measures that are quantitative and qualitative. Usability testing records usage patterns and user reactions.

A usability laboratory was created at the University of Missouri-Rolla. It is supplements the traditional assessment for hypermedia tutorials and virtual laboratories. The laboratory is designed to provide information on user choices and comfort. The test setup provides (1) a time record and progression of intermediate steps and (2) visual and auditory clues to subjective factors. The quantitative measures indicate how efficiently and accurately a user comprehends and navigates. The qualitative measures indicate satisfaction and frustration during the learning process. An example test of a prototype virtual laboratory is described.

Introduction

Product design, including computer software, is shifting from the users need for features to their perception of its overall usefulness.[1] The new terminology is *user-centered design*. A main component of a user-centered design is usability. Usability includes such characteristics as efficiency of task completion, user stress, and user satisfaction. Jacob Nielson described usability of systems as having 5 components.[2] These components are applicable to education software. They are:

- *Learnability* – The user should be able to learn the software quickly, so tasks can be begun quickly.
- *Efficiency* – The user should be able to efficiently perform tasks once they have learned the software.
- *Memorability* – The user should be able to use the software periodically without having to relearn it.
- *Errors* – Users should be able to recover from errors easily.
- *Satisfaction* – Users should feel comfortable with the system and feel that it was useful.

Usability testing records usage patterns and user reactions. A designer can use this data to improve the user interface of any computer software interface.

Industry already incorporates usability testing extensively into the development of products. For example, video game developers have users that play their games to find any previously undetected problems, and to gain insight into what the user would like to see. Recently, usability testing has been incorporated into the development of educational tools in the academic setting. Developers and content providers of these educational tools benefit from collaboration through all steps of the design process. A good design process includes the identification of fundamental concepts and the delineation of concept interrelation, the development of the concept modules, and assessment implementation.[3] The assessment implementation should occur through each phase of the design process. A thorough knowledge of a tool's usability can aid in the development of the tool by identifying characteristics that may hinder the learning process.

Traditional assessments are conducted by comparing learner variables with outcomes such as final grades, quiz scores, or subjective ratings. This type of assessment does not look at the process by which the user came to those outcomes. It also does not record user reactions such as frustration when trying to complete a task. Seeing this process can help designers create user interfaces that are more compatible with the user. Usability testing records the process to allow the designer to see what path the user takes, and what causes the user stress along that path.

The following paper will outline the setup of a working usability testing laboratory and the assessment procedure for computer-user interfaces of educational software. The testing approach will describe the assessment objective and outcomes. The usability testing system used at the Media Research Laboratory at the University of Missouri-Rolla will be given as an example setup.[4] Finally, the setup of an example test will be given as an example.

Testing Approach

The objective of usability testing is to observe user choices and comfort when interacting with a computer interface. Each program or interface has its own set of choices for the user that reflect the content provider's educational aim. For example, a web page will have a menu that the user must navigate to find information. When given a task the user will look for the menu and choose the link that he thinks will help him progress toward his goal. Usability testing can identify the intuitiveness of the path by looking at the length of time and number of choices made to finish a task. Paths and choices that do not distract the user from the task at hand should be retained. Problem features that are identified should be changed. Once a user has successfully completed a task they should be able repeat it much more efficiently. Comfort levels are affected by how choices help or hinder the user's progression, or by things that inhibit the user from easily seeing the correct choice. Things that can affect comfort level include unintuitive hierarchies, gratuitous bells and whistles, and inappropriate colors or fonts.

Usability testing is similar to some traditional assessment in that it looks at how well a task is completed. Unlike traditional assessments it also gives us insight into how the task was completed. Both quantitative and qualitative outcomes can be recorded. The quantitative outcomes are intermediate task completion, navigation and post testing. These include:

- Progression through pages
- Time spent per page

- Number of repeated pages
- Time spent per task
- Number of undesirable occurrences
- Quiz results
- Satisfaction ratings.

Undesirable occurrences are things that the user did not expect. For example the user could get a different response from clicking on a button than expected, or there could be a programming error that closes the program at an undesirable time. The quizzes can be specifically for the usability test, or as part of an assessment for a class. The qualitative outcomes are recorded as subjective responses and relative levels of emotional responses. These include:

- Facial expressions indicating negative or positive response
- Auditory signals
- Locations of pauses in work.

An important feature of usability testing is the correlation of these quantitative and qualitative outcomes.

Testing Procedure and Setup

The setup of a usability laboratory in the Media Research Laboratory at the University of Missouri-Rolla is shown in Figure 1. This setup records a video of the user and the user's screen as well as any auditory signals. The information can be combined or viewed separately. At the MRL the information is viewed as a video capture of the user's computer screen with a simultaneous video of the user in the corner as can be seen in Figure 2. This allows the research to record the facial expressions and movements that correspond to the users interaction with the software.

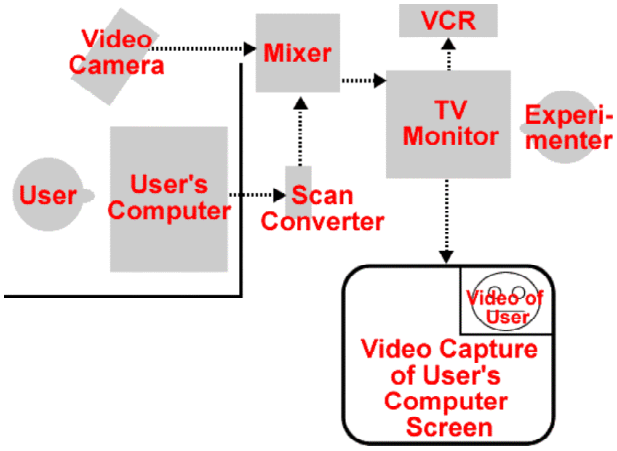

Figure 1: Physical setup of usability laboratory at the Media Research Laboratory.

Figure 2: Video capture of a usability test showing the user and the computer display simultaneously.

Other preparations for the test will be the identification of representative tasks, organization of quizzes and surveys, and selecting an appropriate test group. The tasks are specific to the type of software. Enough tasks should be given that they cannot be completed in the amount of time given. This assures that the user will continue to work. A typical time for a test is 40 min to an hour. The quizzes should be given immediately following the test to insure that there is no chance for the user to see other material. An appropriate test group should represent students that may use the software at their level of study. Usability testing is time consuming both for implementation and review, so the test subjects should be kept to 10-15 users.

Both quantitative and qualitative measures can be determined during testing. The progression through pages, time spent per page, number of repeated pages, time spent on each task, number of other undesirable occurrences, and quiz results are quantitative measures that can be recorded. To obtain these quantitative measures the video is viewed and the measures are carefully recorded. Data could be recorded in a spreadsheet as in Table 1 or Table 2. In Table 1 the time spent on sequence of tasks and the resultant quiz score are recorded. Trends among the test group can be clearly seen. Table 2 is an example record of a user's task progression through a series of web pages. Details for each student in the test group can then be compared. Another example is seen in Table 3 in the Example section of this paper. This data can be shown for each student or for the overall test group. It indicates undesirable occurrences and the number of times they occurred. The researcher should look for large time periods spent on one task or a large number of undesirable occurrences across users, and correlate it with the subjective data in the video. Also the more specific page progression data can then be explored to look for consistent problems across users. Examples of the subjective data are signs of frustration, or interest. There

could be other pauses such as the user stopping to take a drink. Data between users can also be compared according to their learner variables as in traditional assessments.

Table 1: Overall time spent on each task and the resultant quiz scores

Student	**Task 1**	**Task 2 …**	**Quiz**
1	time to complete	:	score
:	:	:	:

Table 2: Task progression for each user.

TASK 1	1st page chosen	2nd page chosen	Overall time	No. of pages visited
Total Time Spent		…		

Subjective response rating questionnaires quantify the user's level of comfort, and add to the researcher's understanding of the other quantitative measures. An example of a questionnaire is given in Figure 3. If given the option to comment, many users will also give good suggestions for improvement that reflect the users perspective.

Please use the following scale to respond to each of the statements:
Strongly Disagree 1 … 2 … 3 … 4 … 5 … 6 … 7 … 8 … 9 … 10 **Strongly Agree**

_____ 1. I learned a great deal of information from the **web site**.
_____ 2. I found the **web site** to be a positive learning experience.
_____ 3. I found the **web site** to be very motivational.
_____ 4. I found the **web site** to cause me a great deal of anxiety and nervousness.
_____ 5. I learned a great deal of information from the **web site** that will be useful in my work as an engineer once I finish my degree.
_____ 6. The **web site** was effective in aiding me in recognizing how much I know and don't know about smart sensors and materials.
_____ 7. The **web site** encouraged me to collaborate with my classmates.
_____ 8. The **web site** encouraged me to integrate information from diverse engineering disciplines.

Figure 3: Example of a response-rating questionnaire.

Example of a Virtual Laboratory Tool Usability Test

One piece of software that has been tested at the Media Research Laboratory is a virtual laboratory. The laboratory was developed in Lab View by programmers at the Instructional

Software Development Center and can be seen in Figure 4.[5] The goal of the usability test was to determine whether students could easily run the program and find information. The software tool was significantly redesigned as a result of the usability testing.

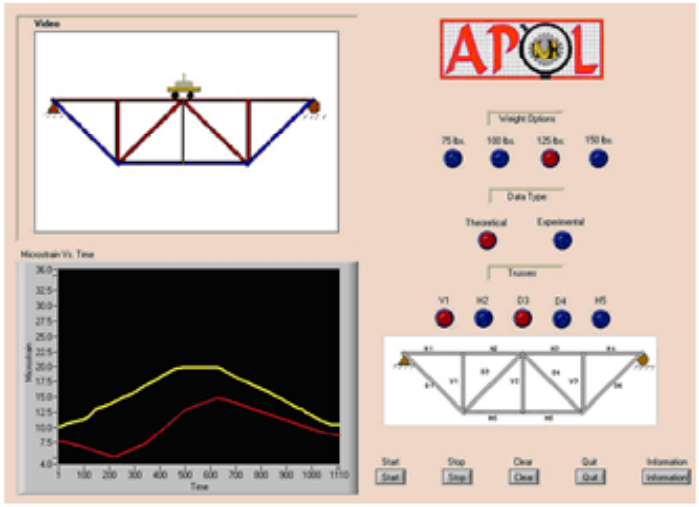

Figure 4: Lab View Laboratory tested in usability lab.

Students were given a set of tasks to complete using the program in the controlled environment. These tasks included:

- Finding information such as equipment characteristics in a help file,
- Tasks in the form of quiz questions determined by running the program.

The students were allowed 40 minutes to complete their tasks. The results of this usability test were useful in determining simple programming errors, navigation problems, poor front panel design, and inconsistencies with typical learning styles. Examples of the problems encountered by the user are in Table 3.

Table 3: Problems seen during video review of LabView program usability test.

	Problems User Encountered	Number of occurrences
1	Reset of buttons	8
2	Scrolling for program and information	8
3	Informational windows	8
6	Accidentally accessing programming code	2
7	Wrong data on graph	2
8	No data showing on graph	5
9	No video feed	6
10	Video feed slower than data graphing	5
11	Corrupt messages	3
12	Extra unusable buttons found	1
13	Closing the program when trying to run	2

The consistent problems were addressed in the next version of the program. A more extensive usability test is scheduled. It will be expanded to include more subjective questions in the form of response rating questionnaires. The time required to do each task will also be explored to correlate it with the user's subjective reactions.

Conclusions

Usability testing can be a very useful tool in the design of all computer software including educational tools. It is time consuming and sometimes subjective, but it offers a different view of the learning process during software use. A usability test can be conducted if the equipment is available using the following steps:

- Determine software of interest
- Determine appropriate test group
- Develop tasks and time constraints
- Record outcomes
- Evaluate results.

The evaluation of the outcomes will help to better design user interfaces in educational software by giving the designer a glimpse into the process by which the user finds information.

1. Barnum, Carol M. *Usability and Testing.* New York: Longman, 2002.

2. Nielson, Jakob. *Usability Engineering.* Boston: Academic Press, 1993.

3. Eller, Vicki M., S. E. Watkins, R. H. Hall, J. Balestra, and A. S. Rao, "Multimedia Web-based Resources for Engineering Education: The Media Design and Assessment Laboratory at UMR" *ASEE Int. Conference Proceedings,* Albuquerque, New Mexico, June 2001.

4. Media Research Laboratory Website: **http://www.medialab.umr.edu**.

5. Eckhoff, Elizabeth, V. M. Eller, R. H. Hall, S. E. Watkins, "Interactive Virtual Laboratory for Experience with a Smart Bridge Test" *ASEE Int. Conference Proceedings,* Montreal, Canada, June 2002.

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