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USABILITY ASSESSMENT OF A WEB-BASED LEARNING SYSTEM FOR TEACHING WEB DEVELOPMENT: A PROGRESSIVE SCAFFOLDING APPROACH

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Abstract

This paper describes a progressive scaffolding approach for the design of web-based learning systems, as well as the development and evaluation of a prototype system that covered web development. Three levels of scaffolding were used: text, graphics, and video. A usability analysis of students' performance with the system found: a) Students primarily relied on video and text scaffolds; b) Performance was positively related to time spent on text scaffolds and negatively related to time spent on video. c) Maximal performance occurred with students who used the scaffolds progressively and systematically.

Introduction

Rationale

Computer based learning systems and the World Wide Web afford us an opportunity to move education to a new level, both to enrich traditional instruction and to provide instruction at a distance. However, research indicates that much of the promise of these systems has not been realized (Reeves, 2002). There are a number of reasons for this. A primary reason is that little thought or effort goes into design and research before the tools are implemented (Hall, Watkins & Ercal, 2000). A fundamental characteristic of effective learning environments is that they promote and encourage active learning. Unfortunately, many web-based distance courses, and even elaborate multimedia simulations are simply used to display information. At the same time, research in hypermedia learning systems indicates that it is also very important to provide the learner with some level of guidance (Shin, Schallert & Savenye, 1994), and this too, is often lacking in these web-based systems. Finally, the ineffectiveness of these tools is almost surely partly due to the lack of systematic research (Dillon & Gabbard, 1998). The vast majority of web-based courses and modules have not been pilot tested or evaluated prior to their introduction into the curriculum. In short, the full potential of web-based learning will only be realized through the application of systematic principles of instructional media design and iterative research (Eller, Hall & Watkins, 2001).

Progressive-Scaffolding System

The prototype system used for this experiment was guided by two fundamental, and somewhat contrasting, design themes: problem-based interactivity; and progressive scaffolding.

In the proposed system, the core of each module is a problem, which requires that the learner actively integrate knowledge from multiple sources and apply basic methods and procedures for its solution. A large body of educational research indicates that learners learn most effectively when they are activity engaged in learning, as opposed to passively reading or listening (Brooks, 1997). Further, problem solving is at the core of meaningful learning.

"Progressive scaffolding" is the term we use to refer to a systematic method of providing learners with and optimal level of guidance (Hall, Watkins & Eller, 2003). The system is designed in such a way that supporting materials are offered in a progressive fashion, from the most general and minimal guidance to the most specific and detailed. It is then up to the learner to select the tool at the necessary level for problem solution.

A Prototype System

We are currently developing a series of learning modules based on the system described above for teaching a Web Development class. The system is intended to support a face-to-face class at the University of Missouri-Rolla on this topic, but it is also intended to be appropriate as a component of a distance learning class.

To begin development of such a system, we first created a prototype module, which is a step-by-step description for how to create a fairly elaborate web page, using the web development tool *Macromedia Dreamweaver©*. To create the page, the user must apply a number of general procedures including: setting up a site; adding tables & graphics; using tables for page layout; inserting text; creating hyperlinks; creating image rollovers; and creating a disjoint swap image behavior.

This initial system is straightforward and is intended to examine the key components of the model posed above. The progressive scaffolding is provided in the form of different levels of information for displaying each step in the development process: a) Text; b) Graphics; c) Narrated Video. The system used for the experiment can be viewed: *http://medialab.umr.edu/web_dev_experiment*. The basic purpose of this experiment was to carry out usability testing on this system in order to address the following two questions:

a) To what extent do users utilize the different scaffolding options (text, graphics, and video)?
b) How does their use of the various options relate to performance?

Method

Participants

The participants were seven students recruited from a General Psychology class at the University of Missouri – Rolla in return for required class credit.

Materials

Students studied an online tutorial, in which they were required to develop a relatively complicated web page, which included links, graphics, image swapping, and disjoint roll over images. The tutorial consisted of a series of pages organized in a linear fashion, and on each page the steps were described in order. In addition to the text, students could view graphic images, which illustrated important parts of the process, and video clips as well. These instructional materials can be viewed on the web at: *http://medialab.umr.edu/web_dev_experiment*.

The experiment took place in the University of Missouri-Rolla's Media Research Laboratory's usability testing facility (*http://medialab.umr.edu/lab*). The facility consists of two cubicles, one for the participant and one for the researcher. The participant's computer screen is dynamically recorded using a scan converter, and facial expressions are recorded via a video camera. These are synchronized via a mixer and stored as picture in picture on videotapes. Such a set up is fairly typical of modern usability laboratories, with the exception that there are not one-way mirrors, nor additional observation rooms (Barnum, 2002).

Procedure

Students were directed to a web page with the following directions:

> *Your goal in this experiment is to create a web site that looks like this (link will open in new window), with the exception that the text should include your name, affiliated organization(s), and links that you would use if you were setting up your own home page.*
>
> *You will set up this site using the web editor Dreamweaver. The program should be open now. (If it is not, be sure and ask the experimenter to open it for you). When you click on the link below a tutorial will open, which will guide you through the step by step process of creating this page in Dreamweaver.*
>
> *The tutorial includes text, graphics, and movies that you can use to aid you in this process. You can use any of the media included in the tutorial that you choose, but keep in mind that the ultimate goal is for you to create the sample site.*
>
> *When the experimenter tells you to do so, click the start button below, which will begin the tutorial.*

(These directions along with the example web site they were told to make can be viewed on the web: http://medialab.umr.edu/web_dev_experiment/start_experiment.htm.)

Students were then given forty-five minutes to complete the web page using the tutorials. Their activity on the computer screen was captured dynamically, in conjunction with a synchronized videotape of their facial expressions.

Results

Time Allocation Analysis

Overall

In order to address the first experimental question, videotapes were scored according to the amount of time that a user spent on four primary activities: 1) Reading text, 2) Viewing graphics, 3) Viewing videos, and 4) Creating the web page. Scoring was carried out such that all of the forty-five minutes that the user spent working had to be assigned one of these tasks. In cases where there was some overlap, such as when the participant was working on the web page, while a video tape was playing, the scorer made a determination as to what was the primary task being carried out at that time and time was then attributed to that task in scoring.

In order to establish reliability, two scorers scored all of the seven tapes and their scores for each of the categories were correlated, and Pearson's r was .70, .97, .68, and .97 for building the web page, viewing the videos, viewing the graphics, and reading text respectively. An overall score was then created for each participant by averaging the scores for the two raters. The percentage time for the four activities averaged across the seven participants was: 49%, 25%, 24%, and 2% for building the web page, viewing text, viewing videos, and viewing the graphics respectively.

Performance

In order to address the second experimental question, the raters also rated the users final web page in terms of quality and quantity (amount completed). In addition, the user's ease of navigation within the tutorial was rated. Again, reliabilities were computed by correlating (Pearson's r) the scores for both raters and these were: .72, .48, .78 for quantity, quality, and navigation.

Pearson's r was then computed between each of the time allocation variables and each of the performance variables and these correlations are displayed in Table 1.

Time	Performance		
	Quality	Quantity	Navigation
Building Page	.57	.31	.20
Reading Text	.32	.60	.54
Viewing Graphics	.32	.23	.20
Viewing Videos	-.44	-.73	-.75

Table 1. Correlation (Pearson's r) Between Time Allocation and Performance

Participant Profiles

Detailed analyses of the videotapes lead to the conclusion that the users' could be meaningfully classified into three general categories: a) Poor performers; b) Good performers; and c) Computer experts. Two users were selected to represent the prototype poor performers, two the good performers, and one the computer expert. For each of these participant profiles, the relevant statistics and representative rater comments are classified and displayed below.

Poor Performers (n=2)

Stats: Time: Task (44%); Text (18%); Video (36%); Graphics (2%)
Performance: Quantity (4.75); Quality (3.75); Navigation (4.00)

These users showed very little motivation beyond frustration, so that they tended to give up easily. With respect to their use of the scaffolding options, they tended to jump around in a relatively haphazard fashion.

Representative Rater Comments: "Showed no real emotion, but seemed lost most of the time"; "Get flustered very easily"; "Did NOT follow directions"; "Jumped around a lot and never really knew what to do".

Good Performers (n=2)

Stats: Time: Task (53%); Text (35%); Video (10%); Graphics (2%)
Performance: Quantity (8.75); Quality (7.00); Navigation (7.75)

In contrast to the poor performers, these users did not get frustrated easily, despite challenges that occurred. They followed the scaffolding options in a systematic fashion, using the text first and relying on the videos only if the text did not work.

Representative Rater Comments: "Did not get flustered very much at all"; "Generally stayed calm"; "Rough at first but quickly improved overall"; "Stayed away from videos unless he was completely stuck."; "Relied on text descriptions"; "Avoided videos unless he was stuck."

Lots of Computer Background (n=1)

Stats: Time: Task (48%); Text (39%); Video (12%); Graphics (1%)
Performance: Quantity (7.5); Quality (5.5); Navigation (7)

This user was particularly interesting since one logical explanation for the difference between good and poor performers was that the former group simply had more computer experience. The behavior of this user was indicative of a good deal of experience, but his performance was relatively average overall. He mainly focused on finishing, rather than following the directions, so that the quality of his performance was poor, though the quantity was high. His behavior indicates that the negative relationship between video viewing and performance was not causal. The videos, in fact, may have been very effective if they were used in a progressive fashion (after the text did not work). In the case of this user he pretty much avoided the video all together, even when it was necessary.

Representative Rater Comments: "Finished, but not everything was right."; "Picked up on most stuff, but rushed through it and missed some of the steps, such as creating disjoint rollovers - he created only plain rollovers"; "He tried to fly through it and this caused him to skip program to program very fast and missed some of the steps; "He shunned the video like the plague and only used it as a last resort."

Discussion

Experimental Question 1: Distribution of Time Across Scaffolds.

Analysis of time spent on the different activities indicates that, overall, users spent about half of their time working on the page, while the rest of their time was divided equally between the use of the most and least minimal scaffolds – the text and the videos. There are at least two explanations for the large amount of time spent reading the text and viewing the videos, in comparison to the photographs. First, three scaffolds in this case may well have been overkill. If the minimal scaffold did not suffice, the user may have decided that the maximal scaffold would be the next logical choice. Why spend time experimenting with multiple levels of scaffolding, when one method has already failed? Second, the fact that the photographs were included in the form of an additional pop-up browser window may have had a big impact on the lack of use of pictures. Had the pictures been more readily available, embedded in the pages, they may have been viewed more frequently. Users may well have decided that, if they were going to open another window, this might as well be a window that includes a dynamic video illustrating the most important next step.

Interestingly, one of the things that the user profile analysis indicated was that the reason students used the videos and text scaffolds was quite different depending on the nature of the user. For example, the good performers appeared to use the video in a truly progressive fashion, when the text would not work. The poor performers appeared to use the video simply because it was readily available to click on. Finally, the computer experts may simply have avoided the video as a matter of principle, regardless of whether or not it was needed.

Experimental Question 2: Effect of Scaffolds on Performance.

The second experimental question focused on the relationship between the time spent on the different scaffolds and performance. The analysis indicated that the two predominantly used scaffolds both had relatively strong relationships to performance in opposite directions. As the percentage of time spent viewing the text increased, so did the performance measures, and the opposite was the case for the percent of time spent viewing the videos. One possible explanation for this finding is that the relationship was causal – text increased, and video decreased, effective performance. The more detailed examination of user's performance in the form of the profiles indicates that this explanation is probably inaccurate. A more likely explanation is that the text was all that was needed for most of the activities, and the video was necessary for some more detailed information. Those who used the scaffolds in this progressive fashion, spent more time on the text and performed well. On the other hand, those that used the scaffolds less systematically, tended to spend more time on the videos and performed poorly. Finally, the profile of the user who appeared to have a great deal of computer experience, indicated that the effective performance of the best performers was not just a result of their previous experience, rather it was their tendency to use the scaffolds progressively, systematically, and effectively.

Conclusions

Taken together, these results indicate that providing students with a progressive set of scaffolding options is a viable way to enhance learning. The results also provide information on some mediational factors, which in turn provide some clues about how to maximize the effectiveness of this approach. First, the number of scaffolds that are to be provided is something an instructional designer should take into account. In this case, users relied almost totally on the most and least minimal scaffolds (i.e., text and video) and ignored the other. Given the finite set of resources available for preparation of learning environments, it's important to recognize that a few scaffolds representing different ends of the complexity spectrum may be enough. Second, the results also indicate that it's important to consider the role of learner variables when using this approach. Providing the learners with progressive options does not guarantee that they will use these options in the most skillful fashion. Those learners that used the options in a progressive fashion performed well, but those who did not performed poorly. This indicates that the method may work most effectively if users are provided with some instruction in how to use the scaffolds before learning, or if the system itself provided more guidance, encouraging and directing users to utilize the scaffolds systematically.

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