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Creating Effective Web-Based Learning Environments: Relevant Research and Practice

by Kay Wijekumar

Web-based learning environments are a great asset only if they are designed well and used as intended. The urgency to create courses in response to the growing demand for online learning has resulted in a hurried push to drop PowerPoint notes into Web-based course management systems (WBCMSs), devise an electronic quiz, put together a few discussion questions, and call it a course. My mentor once quipped that "good learners will learn, in spite of our bad learning environments." Nevertheless, instructors cannot expect that all students will have the skills to navigate online courses and learn within them, particularly if they are only digital reincarnations of poor face-to-face learning environments and practices.

Web-based learning environments can serve as motivational, instructional, modeling, feedback, and assessment tools. These environments also can impact the cognitive and social behaviors of students (Mayer 2001; Wallace 2001). Through a synthesis of research ([Exhibit 1](#)) and practical classroom experiences, I have identified some possible cognitive and social/psychological effects of Web-based learning environments ([Table 1](#) and [Table 2](#), respectively). In this article, I describe the effects in terms of learners, tasks, and tools. My aim is to showcase both the ideal and not-so-ideal outcomes of various online teaching strategies by highlighting relevant research, providing examples of good applications, and suggesting ways in which WBCMSs can be enhanced to accommodate successful educational models. The audience for this article includes instructors and designers of Web-based courses who must change the direction of course development instead of maintaining the status quo.

Learners

Learner Control

Research on learner control indicates that most people need training or assistance to plan, monitor, and focus their learning efforts and make related decisions. For example, Jacobson et al. (1995) found that when students had the option of viewing multiple hyperlinked pages containing information relevant to course content, many chose not to view the pages; these students performed poorly on outcome measures. In another study, students who were forced to review multiple pages in a linear format outperformed counterparts who controlled what they viewed (McKeague 1996).

How can online course instructors encourage students to access relevant reading materials? One strategy is to embed questions within the lesson text to focus students' attention on critical information and persuade them to review notes and readings. Another tactic is to organize Web pages in a linear format, forcing students to view all relevant information. [Exhibit 2](#), a module from Lon Ferguson's graduate-level Principles of Occupational Safety course, demonstrates effective applications of embedded questions. In this module students must review all the notes to find the embedded questions marked by a gearwheel icon; they e-mail responses to the professor for grading. Ferguson, who teaches at the [Indiana University of Pennsylvania](#), works around the constraints of the WBCMS by creating the course with interactions and residing outside of the WBCMS. The courses I have designed and implemented frequently reflect the [cognitive flexibility theory](#) and contain embedded questions or links to databases/spreadsheets. These lessons are implemented on a Windows 2000 server and are available on CD for the students; the lessons link to the WBCMS for discussion board and chat applications.

Because WBCMSs usually provide a compartmentalized approach to presenting information—with notes

under one link, questions under another, and discussion boards under another—these systems generally do not allow instructors to embed activities within notes or reading assignments. Such systems could be improved with a function that allowed instructors to insert prompts and provocative questions within textual material.

Metacognition

Research shows that students need skills to plan and evaluate their learning activities and to synthesize the information they garner (Jacobson et al. 1995; Laurillard 1999). In a traditional classroom, the instructor can model good practices while observing and prompting students. For example, if the topic is how to conduct a good investigation, the instructor can model how he or she would perform the necessary tasks, and then ask students to perform those tasks and advise them on improving their performance. The instructor's actions might include focusing on critical factors/evidence, planning students' investigative steps, outlining alternatives and backup approaches, and monitoring students' progress.

To approximate this modeling process in Web-based learning environments, instructors might create interactions or prompts within their lessons that focus students' efforts on objectives and important skills. When students are unable to reach the goals of learning tasks, expert advice and practical models should be available on demand. Instructors should note, however, that many students invariably will choose not to request help (Jacobson et al. 1995). It therefore may be advisable to log students' actions and/or provide automatic prompts, hints, or advice rather than waiting for students to request assistance.

[Exhibit 3](#) is a sample lesson from an interactive [intelligent tutoring system](#) created at The Pennsylvania State University. In the lesson, which teaches K-12 students a reading strategy (but could be adapted for undergraduate and graduate courses), a humanlike tutor models the strategy and reads a selected passage to the student. The system then solicits an interactive response by asking the student to recall information from the passage. When the student types in a response, the system assesses it and provides informative feedback. Note that the forward button (a dog-eared page) does not appear until the animated agent has finished speaking; this ensures that students listen to the agent before proceeding to the next page.

Current WBCMSs log student activities in terms of the time students spend on each page, but this function could be enhanced further to include the logging of procedural tasks. For example, the quizzing utility could be modified to track the options that students select and then provide suggestions for the next step. WBCMSs also could use other interactive approaches, like CGI scripts or Java servlets, to collect information on student performance and then use that data to prompt or scaffold students. ("Scaffolds" are prompts or hints given to a student who needs help in a given task.) For example, student performance in [Exhibit 2](#) also could include clicking on signaling words or typing in a response that demonstrates recall of a passage; the scaffolds would provide hints about what parts of the passage the student forgot to include. In most instances, the scaffolds would fade away as the student became confident in his or her ability to perform the task.

The Butterfly Defect

Researchers have questioned whether learners generate shallow knowledge structures when viewing information in a hyperlinked format; Salomon and Almog (1998) refer to this as the "butterfly defect." Preliminary research suggests that adults with low verbal ability do not recall critical information from linked Web pages (Wijekumar and Canavesi 2002), and I am conducting additional research to investigate how colored hyperlinks, frames, and other organizational aspects of Web pages affect recall. Anecdotally, when I observe students visiting multiple Web sites and then ask them what they recall from these sites, most students describe images and some features but do not remember specific content.

While a general list of links may prompt students to view Web sites, such a list is unlikely to foster deep knowledge structures. To counter the butterfly defect, instructors can assign specific tasks that encourage

learners to access hyperlinked information with a purpose: to meet specific learning goals. Lon Ferguson's students, for example, must visit the Occupational Safety and Health Administration (OSHA) Web site to find information about guard openings so that they can complete a table or prepare for chat room questions ([Exhibit 4](#)).

As a further means of promoting focused Web research, WBCMSs can be improved with the addition of design hints. For example, when a course designer links to multiple sites, it would be helpful if he or she received a prompt to annotate the links or post a question for each link. If I, as the designer, chose to create a link to the OSHA Web site on machine injuries, the WBCMS would not only ask for the hyperlink but also provide an input box for important questions or comments about the site.

Tasks

Research has shown that active learning requires, at a minimum, student engagement with a realistic task (Herrington et al. 2004). However, many Web-based courses and assignments described as "active" involve only an animated display, a bulletin board, or a chat room. Although these can be effective elements, research on collaborative learning suggests that tasks that require students to merely describe concepts or agree with others do not increase learning (Webb, Tropper, and Fall 1995). In contrast, tasks that invite students to debate issues require deeper thought and more cohesive arguments, resulting in more learning than that achieved by students asked to summarize information (Wiley and Voss 1999). Talking about assignments on a discussion board does not make students active learners, and reading notes, PowerPoint slides, or a textbook does not constitute active learning until the information can be applied in a realistic task. Active learning tasks place students in a realistic problem-solving environment that requires them to perform and learn from various activities.

To facilitate active learning, instructors should design learning environments around realistic tasks. These environments should include any analysis tools that the tasks require, models of good investigative approaches, and scaffolds that can help students complete the assignment. In [Exhibit 5](#), the assignment is to conduct a company accident investigation and analysis. To help students perform this task successfully, there is a step-by-step plan (a modified scaffold) with links to relevant references. Students also receive a printed package containing samples of actual accident records that they can enter into the database linked to this module.

WBCMSs should provide hints and support for instructors and designers who want to incorporate real problems in learning activities. This support can be in the form of templates for problem presentation, scaffolds, and assessment.

Tools

Problem-Solving Tools

Tools are integral to all problem-solving environments (Wijekumar and Jonassen 2002), and Web-based learning environments are no exception. However, the tools that are relevant to learning objectives are not the same as those required to manage course content or course administration. For example, a management course that requires analysis of sales data from multiple stores needs spreadsheets and/or databases, but incorporating such tools into a WBCMS is cumbersome and requires extra programming.

Effective Web-based learning environments incorporate necessary problem-solving tools, as in [Exhibit 5](#). For students to write an accident analysis report, there must be a database to analyze the data. This activity is possible only because I (the designer) created a database with FileMaker Pro outside of the WBCMS, on a separate server, and linked the database to the course.

WBCMSs would be more effective if common tools—such as spreadsheets, databases, word processors,

and concept- mapping programs—could be integrated more easily. At this time, students using these tools must open them outside the WBCMS and upload files to discussion boards or to course folders. Ideally, these tools should be available for file creation and editing within the WBCMS. No system currently provides resources to link any tools. It would be beneficial if a generic set of tools (e.g., spreadsheets and databases) was available, with the ability to add customized tools, such as statistical analysis packages, as needed.

Chat and Discussion Tools

Through communication tools such as discussion boards and chat rooms, WBCMSs have the potential to improve collaboration and learning in Web-based educational environments. However, discussion boards are unwieldy, and chat rooms are used more often as social gathering places than as focused learning tools (Wijekumar 2001).

Chat and discussion tools are more effective when directed by an agenda, as in [Exhibit 6](#). In this example, I assign undergraduate students the task of reviewing information on repetitive stress injuries for computer users. The students have to read information from the OSHA Web site and then review their own posture and computer use. These assignments prepare them for a subsequent chat room discussion about minimizing computer injury risks. I use a round-robin approach for this activity, making sure that everyone in the class participates and that the discussion flows in a meaningful pattern. In particular, I encourage all students to prepare answers in a Word document prior to class, so that during class they can copy and paste their comments into a chat applet. This procedure allows students to concentrate on reading rather than typing when posting their comments, but it does not limit their commentary to responses to previous postings. Advance preparation for the chat room thus helps ensure an elaborated discussion rather than a free-for-all, shallow treatment of multiple topics. It also prepares students for the expectation that, for real-world board or team meetings, they will formulate discussion points and materials in advance.

Incorporating advanced management and reviewing features for discussion and chat utilities would be one way to improve WBCMSs. In chat rooms, it becomes rather complicated when multiple students submit responses, ask questions, and express opinions; chat rooms do not have the advantage of face-to-face conversations, in which people make eye contact and wait their turn to speak. Consequently, the reader typically must sort through many postings in order to sequence them and make sense of the discussion. To allow for easier review of such postings, WBCMS discussion boards and chat functions should support tags that allow postings to be annotated or allow the reader to use keywords to search for themes. Some tools in development (e.g., [Digichat](#) and [ParaChat](#)) allow instructors to organize and moderate discussions by ordering and grouping chat room posts so that the reader does not have to do so.

Seductive Details and Multimedia Learning

Web-based learning environments have a versatile toolset of graphics, video, and audio file formats, but versatility does not always translate to relevance. For example, Harp and Mayer (1998) suggest that unrelated or peripherally related graphics or images can distract lower-ability students, keeping them from concentrating on learning objectives. While gaining students' attention is an important aim of Web-based learning environments, this goal should not detract from imparting relevant content.

To emphasize content, instructors need to focus learning modules on course objectives and downplay peripheral graphics. A module on radiation physics, for example, should concentrate on the topic and not be cluttered with flashy graphics illustrating the blast of an atomic bomb. The [OSHA site](#) referred to in Exhibit 6 effectively uses graphics without distracting the reader. Likewise, because students are easily distracted by simultaneous text and video and cannot process such information through the visual channel alone, instructors might narrate simulations and videos to lessen the perceptual burden on students (Mayer 2001).

WBCMS templates that help instructors and designers learn to minimize the distractive effects of graphics would be useful. For example, if a designer inserted an image file, the system could inquire whether that file

is needed to explain a concept or to motivate students. If the designer confirmed that the image helps explain a concept, then the system would prompt him or her to write or record a relevant description for students.

Conclusion

While Web-based learning environments can be powerful, their potential is often limited by problems of design and implementation. Instructors should stop assuming that all students have the skills to navigate Web-based learning experiences, and they should reevaluate ineffective online teaching strategies. Starting from the research and practical examples presented in this paper, educators can begin to change their approach to Web-based learning. Even if they are dependent on instructional designers and software producers to create their Web-based courses, educators should still find ways to avoid being constrained by the systems they use. They should also insist that these systems accommodate a wider range of teaching styles and preferences, with sufficient tools suited for different instructional needs. The course and the best delivery method should not be distorted to fit into the constraints of generic WBCMSs.

Just as the use of Microsoft Word does not make a better writer, the use of a WBCMS does not make a better online course. WBCMSs do provide a framework for some general design features, allowing instructors to link syllabi, add quizzes, and create discussion boards. But the tools do not automatically translate to a good learning environment. Changes in WBCMSs will come only if instructors and designers push for them. Start that process by asserting pedagogical needs over the glitz of the WBCMS.

[Editor's note: This article was modified from a [presentation](#) at the [EDUCAUSE 2002](#) conference in Atlanta, GA, October 2002.]

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