



Implications of Web-Based Technology for Engaging Students in a Learning Society

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Asynchronous learning resources (ALRs) developed as interactive courseware for the World Wide Web are receiving increasing attention because of the ease with which they can be accessed by students at the time, place, and pace of their choosing. Knowledge-based ALRs are critical for developing the knowledge base essential for problem solving. Problem-based ALRs are especially attractive because of their emphasis on the higher-order cognitive skills of analysis, synthesis, and evaluation. This paper will cover the organization and use of both knowledge-based and problem-based ALRs on the Web.

Interactive Courseware

Many instructional resources available on the World Wide Web are actually electronic texts; a web server is used to publish material that might otherwise be available in hard-copy form. In the author's opinion, interactive courseware differs from electronic texts in several important ways. First, interactive courseware relies heavily on the use of graphics. While traditional texts attempt to use words to "paint a picture" of a concept, interactive courseware attempts to convey concepts primarily through the use of graphics, including illustrations, photographs, photomicrographs, and video segments. Relatively few words are needed to reinforce what each graphic clearly illustrates. Second, interactive courseware concentrates primarily on concepts, as most of the detailed information may be contained in other instructional resources and references, including textbooks. Like the traditional classroom lecture, interactive courseware is intended to complement, not replace, textbooks. And third, interactive courseware is more flexible than the strictly linear format of a textbook. For example, to establish the role soil drainage plays in disease incidence in the pest management chapter of a textbook, one might refer to the edaphology chapter. With interactive courseware, however, one could create a hyperlink for immediate access to the drainage module in any disease module.

Thus, an appropriate definition of interactive courseware might be "computer-accessible, graphic-intensive, and highly flexible instructional resources used to facilitate learning."

Knowledge-Based ALRs

The heart of knowledge-based ALRs are the "instructional modules." These are aggregations of instructional units composed of: (1) a graphic with which to convey a concept, process, relationship, or overview, (2) an associated text, perhaps in scrollable form, depending on the amount of text required, to provide a brief explanation of the graphic, and (3) navigation icons by which to access succeeding (or preceding or looped) instructional units. A series of instructional units covering a particular topic, or a related series of topics, constitutes an instructional module (Turgeon 1997).

There are several types of instructional modules, including the linear type, with simple and complex subtypes, and the flexible type. The linear-type module is composed of instructional units organized in a linear series. Once the student accesses the module, he or she may proceed forward through the series using the forward navigation icon (\rightarrow) to access the succeeding instructional unit. If necessary, the student can reaccess the preceding instructional unit by selecting the backward navigation icon (\leftarrow). At any time, students may elect to terminate their study of the module by using the menu navigation icon. When all instructional units are organized in a linear series, the module is a simple linear-type; however, if some units are organized as loops that can be launched from one of the units in series using the loop navigation icon, the module is a complex linear-type. The flexible-type module is composed of instructional units in which different submenus and graphic/text combinations can be brought up through point-and-click operations conducted on a single screen. The flexible-type modules work well for accessing an array of information and images relating to particular issues or topics, such as specific diseases, insect pests, or plant species.

The specific nature of courseware varies depending on its instructional purpose. For example, instructional modules may be used to support a conventionally taught, lecture-based course in which students may access the modules to: preview the material before attending the lecture, review the material after the lecture, or supplant the lecture when they are unable to attend a particular class. While some students may find the modules a suitable substitute for all lectures, thus obviating the need to attend class except for exams and selected exercises, others find that the modules, used alone, lack some of the essential elements obtained from class participation. A third alternative that appears to offer considerable promise, especially for distance students, is to employ the modules as a constituent of problem-based learning resources organized as "lessons" and "practicums" on the World Wide Web.

Lessons

Lessons can be designed with one or more instructional modules sandwiched between an introductory statement for defining the learning landscape and an exercise which tests the students' ability to apply newly acquired knowledge. The introductory statement can be supplemented with photographs hyperlinked to words or phrases in the text to enhance visualization, and can conclude with a list of questions that establish the lesson's learning objectives.

The third component of the lesson is a formative quiz that tests the students' recall and comprehension of the material covered in the instructional modules. The quiz is developed using a course-management software package called Mallard™, developed by Brown and Swafford at the University of Illinois (Brown and the Board of Trustees, Mallard 1997; Brown and Stafford 1993). Upon completion of the quiz, a student can immediately check to determine which

questions were answered correctly and which were not. Based on the outcome, the student may review the material in the instructional modules and retake the same or a similar version of the quiz, perhaps several times. Through successive iterations of instructional-module review and quiz taking, the student can progressively develop mastery of the material covered in the lessons.

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Practicums

Practicums are problem-centered learning resources by which

students develop the higher-order cognitive skills important in problem solving. A problem may be defined as an "unsettled question." If the problem is expressed in the form of a scientific puzzle, the questions to be addressed might include: What is this, what does this mean, or how does this work? If expressed as a simple technological problem, the questions might be: If this is broken, how can it be fixed, or how can this be made to work better? In a complex system, one must be concerned not only with specific components of the system, but with the array of interrelationships that exist among components; thus, with complex technological problems, the questions might be: If this were done to influence how Component A functions, what might the effects be on Components B and C? Finally, if, as in a case study (Christensen, Garvin, and Sweet 1991), the problematic situation involves people, the important questions could include all of the above plus the following: Will he agree that this is the proper solution, or can she be convinced to allocate the resources needed to implement this plan?

Effectively dealing with problems requires a multiphase process of inquiry (Turgeon 1993). The first phase is *divergence*. This

involves the systematic accumulation of information to accurately describe the problematic situation. If all necessary information is not available, one may be required to fill in the gaps with assumptions regarding key aspects of the problem.

The second phase is *assimilation*. This involves the use of relevant knowledge of concepts, processes, and relationships to properly analyze available information and develop a thorough understanding of the situation. For example, one's knowledge of the etiology of plant diseases would be very valuable in accurately diagnosing a diseased population of plants from symptoms evident in the population.

The third phase is *convergence*. In this phase, issues emerging from the analysis are identified, and various strategies for addressing the issues proposed and evaluated. Also in this phase, decision-making occurs through the selection of an implementation strategy. For example, in a poorly drained soil in which there are sharp textural differences in the profile that interfere with water percolation and aeration, the issue might be: unfavorable conditions for plant growth due to inadequate soil aeration associated with poor internal drainage. A strategy for addressing this issue might then be: extensive tillage and modification of the soil to blend the constituents of the different textural layers, along with some incorporated organic matter, into a uniform, adequately drained medium.

The fourth and final phase is *accommodation*. This involves implementation of the selected strategy for either solving the problem or significantly improving the problematic situation. In complex situations involving people, strategy implementation could involve several functions, including: establishing objectives, organizing work, hiring and instructing personnel in tasks to be performed, motivating personnel to obtain desired performance, and tracking progress and making appropriate adjustments en route. In other words, accommodation may involve the classical management functions of planning, organizing, staffing, leading, and controlling.

Problem-Based Learning

Problem-based learning (PBL) can be characterized as a cognitive process focusing on unsettled questions. In PBL, a particular problem type, such as a scientific puzzle, a technological problem, or a case study, is used to provide students with experience in employing the various phases of the process of inquiry described earlier. While conventional instruction typically focuses on the "lower-order" cognitive skills of recall (memorizing facts), comprehension (understanding concepts), and possibly application (applying concepts to other situations), PBL specifically focuses on the "higher-order" cognitive skills, as characterized by Bloom (1956). These include analysis (enriching understanding through interpretation of facts), which occurs in the assimilation phase, and synthesis (developing solutions) and evaluation (assessing alternative

solutions), which occur in the convergence phase. When first confronting problematic situations, many agricultural-science students move directly from divergence to accommodation as they try to apply "cookbook" solutions drawn from their technological "bag of tricks." In PBL exercises, they can begin to appreciate the importance of detailed analysis and careful planning to effective problem solving as they are led through the process of inquiry by the instructor.

In the face-to-face (F2F) classroom environment, PBL is facilitated by a series of questions posed by the instructor. The processes of asking thought-provoking questions, listening to the students' responses, and responding to their responses, is collectively called "discussion teaching" and is thoroughly explained in a book edited by Christensen, Garvin, and Sweet (1991). Distance students can be engaged in similar discussion classes via interactive television; however, the spontaneity of the discussion is dampened somewhat by the brief lag time between the transmission and reception of each exchange. Where interactive-television facilities are not available, "chat" software can be used as a vehicle for synchronous discussion on networked computers. As an alternative, asynchronous exchanges can be conducted using several variations of electronic mail, including listserves and "groupware" programs (e.g., First Class, Lotus Notes), to engage students at multiple locations. With asynchronous communication, however, the lag time between exchanges can expand to several hours or days, requiring a less-spontaneous, more-calculated approach to discussion teaching.

Another alternative is to incorporate questions directly into Web-based practicums. Following the problem statement, the practicum contains a series of multiple-choice questions designed to lead students through the process of inquiry described earlier. If the student selects the "wrong" answer to a particular question, a response appears indicating that the answer is incorrect, followed by a brief explanation and an invitation to try again. If the "right" answer is selected, a response appears indicating that the answer is correct; this is followed by a confirming explanation, as well as explanations of why the unselected answers were incorrect, and an invitation to proceed to the next question.

Computer-based interactive courseware can be developed to enable students to acquire the entire range of cognitive skills contained in Bloom's taxonomy. Graphic-intensive instructional modules sandwiched between an introductory statement and a formative quiz are used to constitute lessons designed to convey recall knowledge and comprehension. Practicums composed of problem statements and a series of questions for leading students through a disciplined process of inquiry are designed to enable students to acquire higher-order cognitive skills, including application, analysis, synthesis, and evaluation.

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