Professors need to create deep and durable learning in online classrooms. This article offers five principles to help them accomplish this goal.

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Promoting Deep and Durable Learning in the Online Classroom

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If online classrooms are to replace or supplement traditional classrooms, then the responsibility falls to the advocates of online learning to ensure that pedagogically sound practice guides the design and use of online technologies. The question of whether even traditional classrooms manifest sound pedagogical practice notwithstanding, it would be remiss for advocates of online learning to promote it on the basis of expediency and not on quality. Therefore, in this article, we describe five principles of instruction that have been shown by empirical studies to promote deep and durable learning and then provide ways in which each of these principles can be embedded in the online classroom. We will stress ways in which the online classroom can be even more conducive than traditional classrooms to using these learning principles.

There are many learning principles from which to choose, but we narrow our focus to five that have particularly strong empirical support. First, effective instructors require students to become active participants in their own learning by asking them to construct deep explanations, justifications, and reasons for what they think and do. Second, learning is grounded in the effective use of examples. Third, collaborative problem solving increases not only specific problem-solving abilities but general metacognitive understanding of how, when, and why to use problem-solving strategies. Fourth, effective instruction uses feedback that is commensurate with performance (that is, neither too much nor too little feedback is provided to learners depending on their performance). Fifth, effective instruction has embedded within it motivational components that enhance self-efficacy and perceived challenge.

Active Participants in Learning

Advocates of the current constructivist movement in education argue that instruction needs to promote a change in the role of students from passive recipients of knowledge to active constructors of their own knowledge (for example, Greeno, Collins, & Resnick, 1996; Mayer, 1996). Learners must be viewed as meaning makers who actively select, organize, and integrate their experiences with existing knowledge. Learners can be encouraged to become active constructors in many ways. One way is to require students to construct deep explanations, justifications, and reasons for what they think and do (Graesser, Person, & Magliano, 1995). "Interaction that consists of the mutual exchange of ideas, explanations, justifications, speculations, inferences, hypotheses, conclusions, and other high-level discussion promotes the construction of new knowledge" (King, 1997, p. 224).

To promote students' active construction of knowledge, professor-student and student-student interactions must be focused on deeper levels of understanding. This can be accomplished by requiring students to generate and verbalize their own explanations (Dominowski, 1998; King, 1997; Pressley, El-Dinary, & Brown, 1992). Acquiring new knowledge by articulating in one's own words how the new knowledge fits with existing knowledge has been shown to increase comprehension (King, 1994; Pressley, Wood, Woloshyn, Martin, King, & Menke, 1992).

A central feature of online classrooms is access to a variety of telecommunications tools. (See Article Three in this volume for more on this.) These tools provide opportunities for professor-student and student-student interactions to take many different forms that can promote active construction of knowledge through discussion. For example, e-mail can be used to develop individual question-response-clarification cycles between professor and students or among students. Deep questioning, with regular and timely responses, followed by clarifications of incomplete or erroneous knowledge, can promote high-quality and thoughtful e-mail interactions. E-mail discussions may actually produce more insightful discussion of ideas than face-to-face interactions because participants have the opportunity to frame, reflect on, and revise questions and responses before sending them (Harrington & Hathaway, 1994).

However, maintaining individual online question-response-clarification cycles with students can be extremely labor-intensive for professors, especially in classes with large enrollments. One way to lessen this burden on professors is to use group discussion forums like e-mail-based listservs or bulletin board–style newsgroups. A professor can send a single message—a question on an assigned reading, for example—to the listserv, and all students who are enrolled in that listserv will receive a copy. Student replies are also posted to the listserv so that all participants have access to the responses. Students then may choose to integrate peers' ideas into their responses by agreeing or disagreeing with the multiple perspectives rep-

resented. Thus, a discourse grows that does not depend on professor intervention. All participants take responsibility for the conversation as they strive to explain their thoughts, develop and justify their ideas, and question each other to negotiate meaning within the listserv.

Newsgroups provide a more structured format that allows professor-student and student-student discussion to be "threaded." This means that replies are arranged hierarchically so that the reader can determine the threads that run through a discussion. For example, a professor might pose a question like this one: "How are issues of justice addressed in Hawthorne's *The Scarlet Letter?*" One thread could be started with a student initiating a discussion about legal interpretations of justice. Other students could respond to this student and each other on this topic. Another student might begin another thread on ethical justice, and students could respond within this thread as well. The threading is represented graphically, so that readers can track the threads of the discussion through the various issues that are raised. Threaded discussions can be conducted on public newsgroups and also have been incorporated into Web-based course development programs like WebCT (Goldberg & Salari, 1997).

Asynchronous communication tools like listservs and newsgroups provide opportunities for students in online classrooms to engage in high-level discussions by framing and presenting ideas, formulating challenging questions for peers, and responding to those questions to clarify misconceptions that arise. Thus, students learn to develop reasoned responses that include explanation and justification. Students also learn to devise and respond to questions that require answers based on integration or synthesis of disparate chunks of knowledge, logical connections, and causal or goal-oriented reasoning. Caution is warranted, however, because these forms of communication lack important features that are present in face-to-face interactions. (See Article Seven in this volume for more on personalizing electronic communication.) Students may need explicit instruction to participate effectively in group-based, online communication forums. Developing supportive online communities can be promoted by establishing guidelines for Internet etiquette, or "netiquette" (see McMurdo, 1995; Scheuermann & Taylor, 1997).

Effective Use of Examples

The second learning principle—teaching through the use of examples—has a history as long as instruction itself. The two dominant psychological paradigms of the twentieth century, behaviorism and cognitivism, continue to place critical importance on the role examples can play in learning. Although the two paradigms differ in how examples are used, the ultimate goal of each is to enhance the generalizability or transfer of the critical elements learned in examples to new contexts. Behaviorists have argued for the presentation of well-structured, positive, and negative examples that

focus on the critical common elements of concepts or skills (Butterfield & Nelson, 1989). Some cognitivists, however, argue for the use of contextualized and authentic anchored cases, that is, examples drawn from real-world experiences of students (see Brown, Collins, & Duguid, 1989; Vye, Schwartz, Bransford, Barron, Zech, & CTGV, 1998).

The behaviorally guided use of examples in computer-based instruction during the 1960s and 1970s met with limited success. However, recent work has shown that the use of examples that are anchored in contextualized and authentic cases can lead to improved educational outcomes (for example, Williams, 1992), and that case-based instruction may be well-suited to computer-based technologies (Anderson, Conrad, & Corbett, 1989; Vye et al., 1998). Anchoring instruction in specific real-world experiences promotes problem finding and solving, exploration, discovery, metacognitive processing of problem solving, and the transfer of learning (Vye et al., 1998).

Even though the use of case-based examples in distance education is relatively untested, general principles can guide their use (Graesser et al., 1995). Authentic cases (for example, determining the best way to spend $100 for a week's worth of groceries) are better than concrete cases (calculating how much rocket fuel is needed to get a two-ton payload into space), and concrete cases are better than symbolic cases (manipulating the variables in the equation $f = ma$). Regardless of the kind of case that is selected, beginning instruction should start with a case that is more generic or prototypical in nature to foster near transfer, but then should shift to cases that are more unusual to promote far transfer (Butterfield & Nelson, 1989). Cases that illustrate early learning skills should use simple simulations, and cases that illustrate advanced skills should use complex simulations (Bjork, 1994; Mayer & Sims, 1994). Finally, multiple cases with similar goals and that require similar processing should be used to increase perceived similarity among cases and increase transfer among them (Bjork, 1994).

Before using case-based examples in the online classroom, the professor must make decisions about selecting appropriate case formats, delivering the cases to students, and conducting case discussions with and among students. Once the professor has determined the type of case-based example to use (for example, an authentic prototypical case that illustrates early learning skills), an appropriate format can be chosen for presenting the case. For instance, some content can be presented using a written format. A growing number of case-based resource books are currently available (for example, Barnett, Goldstein, & Jackson, 1994; Shulman, 1992) that include written vignettes on a variety of topics across content areas. There is also evidence that video clips provide an effective format for case presentation (Richardson & Kyle, 1999). Video cases can be produced by videotaping specific examples of practice, or they may be purchased as stand-alone materials or as supplementary materials that accompany textbooks (for example, Eggen & Kauchak, 1999). Finally, computer software packages have been

developed that include video case examples, which are integrated with activities and supporting materials (for example, Bowers, Barron, & Goldman, 1994; Goldman & Barron, 1990).

After the format for presenting the case has been selected, the online professor must decide how to deliver case examples to students. Text-based examples can be e-mailed to students or posted to a listserv or newsgroup. Students can download short video case examples or view video clips online. Although not all professors will have access to TV broadcast facilities, those who do could broadcast their case examples to remote sites. Finally, case-based videos or software can be assigned as a required text that students would purchase along with their other course texts and materials.

Discussing the issues and problems that are raised through a good case example is an essential component for promoting deep and durable learning from cases (Barnett, 1998; Harrington & Hathaway, 1994; Merseth, 1996). Case discussions can be conducted in the asynchronous formats described earlier. Students can be divided into small groups or participate in whole-class discussions. Newsgroups and other "threaded" discussion forums, like the bulletin board feature in WebCT online course development software (Goldberg & Salari, 1997), can be particularly effective in promoting rich and connected discussions because participants have time to read and reflect on their peers' ideas before posting their own messages (Harrington & Hathaway, 1994).

However, asynchronous formats also open the door to potential miscommunications. Because it is not just the words that carry meaning but how those words are spoken, it is sometimes difficult to recognize nuances like irony, sarcasm, or humor without seeing or hearing the actual speaker (again, see Article Seven in this volume). One way to address this problem is to conduct case discussions using desktop videoconferencing software like CU-SeeMe. This software allows participants at different sites to see, hear, and talk to each other using a computer, video camera, and Internet connection. The entire group can meet online, or if small groups are located at different sites, participants at each site can discuss issues with others at the site, then present their ideas to the larger group using videoconferencing technology.

Collaborative Problem Solving

Research on expert-novice collaboration and peer collaboration has shown that collaborative problem solving can increase specific problem-solving abilities and general metacognitive understanding of how, when, and why to use problem solving strategies (Daiute & Dalton, 1993; Greeno, 1991; Lave & Wenger, 1987). "During such interaction with another [collaboration], we clarify ideas, negotiate meaning, develop new skills, and construct new knowledge; thus, learning becomes a by-product of that interaction" (King, 1997, p. 221).

In order to foster collaboration, communications need to involve an interactive construction of knowledge between or among individuals rather than a simple taking of turns. Through mixed initiative dialogues, "meanings accumulate collaboratively and incrementally with ongoing repair" (Graesser et al., 1995, p. 367). Mixed initiative dialogues allow the learner to play a dual role. As speaker, the learner can articulate his or her understanding to the listener and receive feedback on that understanding; as listener, the learner judges the speaker's articulations against his or her understanding and provides feedback that either confirms or disconfirms the speaker's understanding.

The extent to which the distance education environment can support collaboration and mixed initiative dialogue depends, in part, on several key components that have been identified by Brown et al. (1989). First, the kinds of problems given to students must require collective problem solving. Presenting problems that could just as easily be solved by one person working alone as by a group working collaboratively will not only frustrate individual motivation but will undermine the collaborative process (Webb & Palincsar, 1996). Second, students must be provided with opportunities to understand the different roles needed to solve a particular problem and to reflect on how the different roles contribute to a solution. And third, efforts must be made to ensure that misconceptions and ineffective strategies are in fact being repaired through collaboration and mixed initiative dialogues.

The professor can design activities to provide collaborative problem-solving opportunities in the online classroom. For example, students can participate in developing and presenting group projects online. Information-sharing programs, such as CSILE (Scardamalia, Bereiter, Brett, Burtis, Calhoun, & Smith Lea, 1992; Scardamalia & Bereiter, 1996) and Lotus Notes (Kittner & Van Slyke, 1997), can be used to store student productions in one database to which all users have simultaneous access. Students can complete project-based assignments in which they select or are assigned different roles in gathering information and resources. They can then use communication software to work collaboratively and organize a project into a presentation for their peers or the professor. Presentations of projects can be made online using conferencing software like ClassPoint or NetMeeting.

Online educational research projects also provide opportunities for students to collaborate on the Web. Access Excellence (National Health Museum, 1999) provides a forum for participating in three types of online projects: collaborative projects, which facilitate the exchange of information and materials between classrooms; data collection projects for collecting and comparing data between classrooms; and research projects for developing and initiating an original research question in collaboration with research scientists. For example, a data collection project might involve students from across the United States in gathering and analyzing data on topics like acid rain or the strength of the sun's rays. Students collaborate to create a

database that allows them to discern patterns in the national data that would not be possible if only local data were available.

Effective Use of Feedback

The fourth learning principle is that effective instruction uses feedback that is commensurate with performance. In their review of computer-aided instruction (CAI), Kluger and DeNisi (1996) conclude that CAI programs that provide feedback interventions to learners sometimes impair learning compared with programs that provide no feedback interventions. These authors explain that too much feedback may eventually serve as a crutch for the learner. Rather than learners using feedback that is generated from performing the actual task, they may come to rely on feedback generated from the CAI program to alert them to errors. Although it is important for learners to receive feedback to help reject erroneous performance, too much feedback may prevent them from learning how to regulate their performance on their own.

Researchers with instructional interests other than CAI also have come to the conclusion that withholding or reducing feedback in some cases may encourage greater learning (Bjork, 1994; VanLehn, 1990). Students need opportunities to discover their errors and repair them. Too much feedback given too soon can disrupt this discovery-and-repair process and lower student motivation to become self-directed learners (Graesser et al., 1995).

Furthermore, tailoring feedback to meet individual student needs is a difficult task, even in one-on-one tutoring (Person, Graesser, Magliano, & Kreuz, 1994), and may be more difficult in the distance education environment. Student isolation, inherent in the online classroom, makes giving effective feedback a central concern. Although students need to take responsibility for their own learning and become self-directed learners, they also need support, structure, and clarity from the professor.

Online professors can provide support systems through Web-course authoring systems like WebCT (Dabbagh & Schmitt, 1998). A detailed course calendar, syllabus, assignment list, and frequently asked questions (FAQ) section provide structure and information so students have complete information about the professor's expectations for the course. Students can be encouraged to seek peer feedback through discussion groups before contacting the professor with their questions. This encourages them to self-regulate their need for feedback and to access different sources of feedback rather than rely on a single authority. Professors can regularly monitor these discussion groups and participate when needed. If students are sharing misconceptions, or if the discussion is proceeding in unfruitful ways, the professor can intervene to provide constructive feedback. WebCT also provides an online grading sheet, allowing students to get feedback on their progress in the course at any time. A dedicated e-mail system within WebCT provides an important feedback loop between professor and students.

Motivational Components

The importance of motivation in learning cannot be overstated. Without motivation to learn, learning becomes a sterile process that is externally dictated and internally resisted. Therefore, effective instruction, regardless of the kind and context, must have within it motivational components that enhance self-efficacy and perceived challenges. Although the novelty of using technology per se may be motivating for some, steps may need to be taken to help others become motivated to engage in online learning. We believe that the previous four principles of instruction serve well not only as ways to enhance learning but also to enhance motivation to learn.

Requiring students to construct deep explanations, justifications, and reasons for what they think and do encourages them to become active participants in their own learning. The more active they become, the more willing they may be to engage in riskier and more challenging tasks, and when they are more willing to engage in riskier and more challenging tasks, the more self-efficacious they will become (Bandura, 1989). Self-efficacy, challenge, and motivation also can be encouraged by allowing students to select their own problems from a collection of problems (Lepper, Woolverton, Mumme, & Gurtner, 1993). Students could start with any problem from a collection of problems and determine their own path through the remaining problems.

Being involved in collaborative problem solving allows students to view their knowledge and skills in comparison with others (Daiute & Dalton, 1993). Therefore, collaborative problem solving provides students with opportunities to judge their subjective level of challenge on a task against how others perceive the challenge of the task. By reflecting on their own abilities against this backdrop of others' abilities, learners can gain a better understanding of their weaknesses and strengths. Knowing their strengths may motivate them to engage in problems that focus more precisely on their strengths.

Finally, in addition to providing neither too much nor too little feedback, the feedback that is provided could be designed to promote self-efficacy. Based on their analyses of expert human tutors, Lepper et al. (1993) have made three recommendations for enhancing student self-efficacy. First, professors should avoid direct negative feedback when telling students that they are wrong or that their efforts have not been fruitful. Instead, professors should guide students to the correct answer by providing hints and other more indirect feedback. Second, they should enhance students' successes through judicious use of praise for success. When praise is used, professors should be sure to note how difficult or atypical the successful problem solving was. Finally, professors should minimize failure by sharing responsibility for the failure or by indicating that the problem was unusually difficult.

Conclusion

A central question that we sought to answer in this article is whether deep and durable learning can occur in the online classroom. Although rigorous tests of the effectiveness of online classrooms have yet to be performed, we believe that providing pedagogically sound instruction online is already possible and has great potential to improve. The five principles of instruction that we have identified are a small but select group of principles that have received strong empirical support as being critical to learning. We have proposed practical ways in which these five principles can be embedded in online instruction.

However, we do not guarantee that these methods will lead to deep and durable learning. Learning will not necessarily occur just because a professor uses listservs, interactive video, information-sharing software packages, or desktop videoconferencing software. (See Article Eleven of this volume.) There is no substitute for reflective instructional practice, and it is up to the professor to reflect on whether students are learning and how they are expected to learn. There are great differences in the ways in which people construct knowledge, and there are equally large differences in the ways in which knowledge is constructed in different domains (Chi & Ceci, 1987). Some individuals may be well served by online delivery of instruction, but others may find online learning foreign.

Some of the ways in which online instruction can be delivered have great potential and may eventually prove to be more effective than traditional instruction. However, even if online classrooms only do just as well as traditional classrooms, advocates of online instruction have done their jobs. Still, an important question that continually must be kept in mind is whether the online classroom hinders learning. If the answer to this question is yes, then we must take a step back and seriously investigate what we are advocating.

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