Educating Engineers On-Line: Strategies and Lessons Learned

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Abstract

The combination of varied technology options and societal factors caused a significant increase in the number of students enrolled in on-line learning over the past decade. Despite the growth, many educators and students continue to ask if on-line learning is as effective as traditional face-to-face delivery methods. A recent study at Southern Polytechnic State University compared grades for course taught on-line with the same course taught on campus, and found no statistical differences in the grades received. However, the most common criticism of on-line courses by students who participate in both on-line and on-campus courses is that the on-line courses lack the depth and breadth of on-campus courses. Perhaps another way of viewing these results is that the students were meeting the on-line instructor's minimum expectations for achievement, but the instructor and on-line course were not meeting the student's expectations for learning. The authors labeled these phenomena *vertical learning* (the instructor's expectations for achievement) and *horizontal learning* (the student's expectations for learning). Obviously, good instruction should include both regardless of the delivery method. Based on a review of the literature, student feedback, and personal experience, the authors identified and implemented the following vertical and horizontal learning strategies for on-line courses: 1) provide clear and measurable learning objectives, 2) provide a detailed course syllabus, 3) organize students into small project teams, 4) foster peer collaboration by using a team project and peer evaluation, 5) include problem-solving activities and "real-world doing" in student projects, and 6) evaluate student mastery of learning objectives. External consultants, students, and the instructors evaluated the implementation of the learning strategies. Lessons learned and improvements were identified for future course offerings.

Introduction

A review of current trends in higher education places distance education at the forefront. Distance education is defined as a learning environment where the instructor and students are separated by physical distance (Willis, 1994). Traditionally, distance education consisted of primarily print-based materials with most instructor/student interactions being transmitted by the postal service. Within the past decade, traditional methods were supplanted by technology. Willis (1994) notes the following technological options available to the distance educator:

- *Voice—Instructional audio tools include the interactive technologies of telephone, audio conferencing, and short-wave radio. Passive audio tools include tapes and radio.*
- *Video—Instructional video tools include still images such as slides, pre-produced moving images (films, and video), and real-time moving images combined with audio conferencing (one-way or two-way video with two-way audio).*
- *Data—Computers send and receive information electronically. For this reason, the term "data" is used to describe the broad category of instruction tools. Computer applications for distance education are*

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varied and include computer-mediated education (computer applications facilitate the delivery of instruction such as electronic mail and real-time computer conferencing) computer-managed instruction (computer is used to organize instruction and track student records), and computer assisted instruction (the computer is used as a self-contained teaching machine).

The combination of varied technology options and societal factors caused a significant increase in the number of students enrolled in distance education during the past decade. *Newsday*, in citing a U. S. Department of Education report released in July 2003, noted that enrollment in distance education courses in higher education topped three million in 2001 (VanNess 2003). In an article in *U.S. News and World Report*, Boser (2003) stated that enrollment in distance education increased by 20 percent in 2003 with eleven percent of postsecondary students taking at least one course online. The number of students participating in distance learning is expected to continue with Congress poised to remove the last obstacles preventing distance students from qualifying for the same federal financial aid as traditional students (Boser, 2003). The increase is expected to be most noticeable in computer-mediated instruction also known as e-learning or on-line learning.

Is On-Line Learning as Effective as Traditional Delivery Methods?

Despite the predicted increases in enrollment, many educators, lawmakers, and the general public continue to ask if distance education and on-line learning are as effective as traditional face-to-face delivery methods. Some critics even quipped that on-line learning "is education by sound bites."

Allen and Seaman (2003) noted that, in the past, online learning was perceived as always being inferior to traditional face-to-face instruction, and that that belief was widely held. However, the results of their 2003 survey of academic leaders conducted through the Sloan Consortium found that the respondents put on-line learning and face-to-face instruction "on very close terms today, and expect the online offerings to continue to get better relative to the face-to-face option." In fact, "a majority of academic leaders (57 percent) already believe that the learning outcomes for online education are equal to or superior to those of face-to-face instruction." However, Allen and Seaman also asked those same academic leaders if their faculty would embrace on-line education as a delivery method. They found that "academic leaders at a majority of institutions (59.6 percent) agree that their faculty accept the value and legitimacy of online education, however, this leaves over 40 percent of institutions that are neutral or disagree with this statement." In fact, Boser (2003) noted that some respected institutions such as Columbia University struggled to attract students to courses. Boser concluded, "the fantasy of instructor-less education soon faded as courses with little or no personal interaction—sometimes just the content of books plunked onto Web sites—posted dropout rates as high as 60 percent."

The graduate faculty at Southern Polytechnic State University pioneered the use of the Internet for graduate education in Georgia starting an on-line Master of Science in Quality Assurance (MSQA) program in 1997. During subsequent years, the success of on-line MSQA courses varied, as did student feedback. In an effort to determine if differences existed between on-line courses and face-to-face courses, Montgomery (2000) compared grades for MSQA courses taught on-line with the same courses taught face-to-face. He found no statistical differences in the grades received. The reader could infer that the instructor expectations for student achievement were being met regardless of delivery mode. However, a review of MSQA student feedback found that the most common criticism of on-line courses by students who participated in both on-line and face-to-face courses is that on-line courses often lack the depth and breadth of face-to-face courses. Perhaps another way of viewing these results is that the students were meeting the on-line instructor's minimum expectations for achievement, but the instructor and on-line course were not meeting the student's expectations for learning. The authors labeled these phenomena *vertical learning* (the instructor's expectations for achievement) and *horizontal learning* (the student's expectations for learning). Obviously, good instruction should include both regardless of the delivery method.

More to the point, if on-line learning is to be equal to or superior to face-to-face instruction, it must encompass both vertical and horizontal learning!

Strategies for Vertical and Horizontal Learning in On-Line Courses

Inclusion of both vertical and horizontal learning in on-line courses necessitates the adoption of a new paradigm regarding the role for the instructor and the structure of courses. As Roby (2002) stated more simply,

> *From a higher-education perspective, . . . conducting an online course . . . requires instructors to reevaluate their approaches to lecturing, designing instructional materials, facilitating student collaboration, mentoring individual students, and evaluating student performance.*

The Institute for Distance and Distributed Learning at Virginia Tech provides guidance online to assist instructors in developing and delivering on-line courses. The guidance is included in the *Handbook and Tools for Distance Education Instructors*. One of the topics in the handbook is "Managing Student Expectations." The handbook is quite clear in its guidance on the necessity of course learning objectives as it states "In the distance environment it becomes increasingly critical that you identify your course objectives in very clear terms. What will the student be expected to do to demonstrate mastery of your objectives? When will they be required to do this? Because of the physical distance separating you from your students, their need to clearly understand what it is you want will be accentuated."

The Virginia Tech handbook further states that the learning objectives are to be measurable and referenced repeatedly throughout the course. The handbook also suggests that the instructors provide ample practice opportunities with feedback before requiring students to demonstrate mastery of the learning objectives.

Alley (2001) notes that on-line courses should be more "student-centered," that is on-line courses should help students construct knowledge, not simply transmit information. He further states "the web site [should be] designed as a learning environment for students, rather than a bulletin board upon which to post cognitive knowledge." Alley adds that on-line learning should include "real-world doing" by providing a variety of off-line activities for students to become active learners. He recommends that on-line courses include a mix of solitary study and group learning. Alley also recommends that course syllabi be significantly more detailed in terms of timetables, learning tasks, and learning outcomes than syllabi typically found on-campus. He notes on-line students need to be "much more thoroughly aware of the course design and each specific competency definition."

Hootstien (2002) notes, "the emergence of e-learning comes at a time when education and training are undergoing important transformations. The teacher-centered model that has dominated instruction for centuries is slowly giving way to a learner-centered model with instructors in the roles of facilitators . . ." He further states "the essential quality of learner-centeredness is most relevant when learners are personally challenged with a problem to solve, a project to complete, or a dilemma to resolve." Hootstien adds "realistic problem-based experiences make content more personally meaningful for learners." He recommends providing timely and personal feedback to students on their performance and the quality of their work. He notes "feedback is even more critical to e-learning than traditional classrooms because learners may feel isolated and detached due to lack of environmental and nonverbal signals." Hootstien also recommends that instructors incorporate collaborative learning in their course strategies "developing a sense of community within and between small groups." He states, "underlying [collaborative learning] is the belief that learners achieve best in social interactions based on consensus building and cooperation.

Hootstien's thoughts were confirmed by Roby (2002). Roby's doctoral dissertation examined the perceptions of ten instructors in the University System of Georgia regarding successful and unsuccessful peer collaboration exercises that occurred with their on-line courses. A set of heuristics for successfully including peer collaboration in online courses also evolved from the study including the following items: organize student groups, create groups of three to five students, monitor and facilitate online collaboration exercises constantly, provide feedback often, and promote peer collaboration through grading.

A Summary of Ten Strategies

The strategies for including both vertical learning (meets instructor expectations for achievement) and horizontal learning (meets student expectations for learning) in on-line courses are summarized as follows:

- Provide students clear and measurable learning objectives
- Provide students ample and frequent practice opportunities with feedback before requiring them to demonstrate mastery
- Provide an in-depth course syllabus that includes detailed timetables, learning tasks, learning outcomes
- Include a mix of solitary study and group learning
- Design the web-site to be a learning environment for students, not a bulletin board for cognitive knowledge
- Promote peer interaction and collaboration through group projects, grading, and peer evaluation
- Organize students into small study/project teams of three to five members
- Structure off-line student project that include problem-based learning activities and "real-world doing"
- Provide frequent and critical feedback based on student performance in individual and group work
- Require students to demonstrate mastery of learning objectives

Application of Vertical and Horizontal Learning Strategies in On-Line Courses

The authors applied selected strategies to a MSQA course taught on-line at Southern Poly during Summer Semester 2003. QA 6630, *Technical Training Methods*, is a required course in the Master of Science in Quality Assurance program and an elective course in the Master of Science in Technical Communication program. The course focuses on a process for developing and implementing adult training programs. The course content is divided into five major areas—determine training requirements, design training specifications, develop training materials, implement training and student evaluation, and assess the effectiveness of training. The application of adult learning theory, management of training processes, alternative training methods and settings, and assessment techniques are integrated into the course content. QA 6630 is also taught on campus.

Strategy 1: Provide Clear and Measurable Learning Objectives

The authors developed 17 course learning objectives for QA 6630 following the process devised by Mager (1997). Mager defines a learning objective "as a collection of words . . . intended to let others know what you intend for your students to achieve." He further states the following about a learning objective:

- *It is related to intended outcomes, rather than the process for achieving those outcomes.*
- *It is specific and measurable, rather than board and intangible.*
- *It is concerned with students, not teachers.*

Mager notes that a clear, measurable, and observable learning objective includes three parts—performance, conditions, and criterion. Performance "describes what the learner is expected to do." Conditions "describes the

conditions under which the performance is expected to occur." Criterion "describes the level of competence that must be reached or surpassed."

The following are selected examples of course learning objectives from QA6630. (Note that the performance statement is written in **bold face** type, the criterion is written in *italics* type, and the conditions are written in normal type.)

1. Without notes or references, **draw and label the systematic approach to training (SAT) model** *without error*.

2. Without notes or references, **describe at least five distinctions between performance-based training and conventional content-based education** *without error*.

3. Given a job hierarchy diagram that includes a list of tasks required for proper job performance, **select tasks to be trained** *based on importance, difficulty and frequency*.

4. Given the skills and knowledge necessary for successful performance of task, **write learning objectives that define the knowledge a student is expected to master during training**. *Learning objectives are to be written as measurable action statements supported by conditions and standards.*

5. Using learning objectives, appropriate measures of student mastery, and instructor and student learning activities, **develop a training guide (lesson plan, laboratory/shop guide, OJT guide)**. *The training guide is to include learning objectives, a content outline, instructor notes, and student activities and promotes student mastery of learning objectives.*

Strategy 2: Provide a Detailed Course Syllabus

A detailed course syllabus was developed and posted on the course web page approximately one month prior to the start of the semester. The syllabus for Summer Semester 2003 included a course description, 17 course learning objectives, protocols on demonstrating knowledge mastery, directions for group and individual projects, directions for chat rooms, expectations for academic honesty and student work, texts and other reference materials, and a weekly timetable with topics, assignment deadlines, and suggested readings.

Strategy 3: Organize Students into Small Study/Project Teams

During the Summer Semester 2003, 28 students registered for the QA 6630 (on-line). The student locations included London, England, Seattle, Washington, Arlington, Virginia, Tampa, Florida, Jackson, Tennessee, and various locations in Georgia. To provide a sense of community and to facilitate sharing, interaction and collaboration, the students were organized into seven teams of four members each during the first week. Each team was asked to select a team name (i.e., "Lean and Mean" and "Turbo"). The team names aided the instructors in identification of the teams as well as provided a sense of *espirit de corps* for the team members. The teams were kept in tact throughout the semester and served as the focal point for chat rooms and a team project.

Strategy 4: Foster Peer Collaboration by Using a Team Project and Peer Evaluation

As noted above, small teams were organized during the first week of the semester. Immediately following, the teams were directed to begin work on a team project. The project consisted of applying a systematic approach to analyzing and designing training for a fictitious job position. Individual team responsibilities included the following steps:

- Develop a position description for the position.

- Complete the analysis activities for the position as specified in the course learning objectives 2-4. .
- Complete the design activities for the position as specified in the course learning objectives 5-10.
- Complete the development activities for the position as specified in the course learning objectives 11 and 12.

Written documentation was required at the completion of each step to demonstrate team mastery of the learning objectives. The instructors provided timely and constant feedback to each team member via e-mail and as necessary by telephone. The feedback acknowledged demonstration of mastery or detailed specific improvements needed to the team's input to demonstrate mastery. Additional feedback and coaching were provided via telephone and face-to-face meetings based on student requests. The team project constituted 35 percent of the students' final grade.

At the completion of the team project, each team members was asked to evaluate the other members of the team in terms of participation and contribution to the team effort. Specifically, members rated their respective teammates on "knowledge of the subject matter," "contribution to project," "quality of input," "participation in team meetings," and "attendance at team meeting" using a Likert scale of one to five. Each team member's scores were summed, averaged, and the converted to a percentage value. Each team member's percentage value was multiplied by 35 to determine the student's individual grade for the group project. (For example, Group A's score is 31 of the 35 possible points. Group A member JTC receive a "contribution and participation" rating of 90 percent by the other team members. To determine JTC's individual score, we multiply 31 times 0.90. The result is 27.9. Therefore, JTC's individual score is 27.9 of the 35 possible points.)

Strategy 5: Include Problem-Solving Activities and "Real-World Doing" in Student Projects

As noted above, the team project consisted of completing analysis, design, and development activities for a fictitious position. The individual project consisted of applying a systematic approach to designing, implementing, and evaluating training for a job position at the student's place of employment. Written documentation was required at the completion of each step to demonstrate individual mastery of the learning objectives. In addition to completing analysis, design, and development activities for the position as specified in the course learning objectives 2-12, the student was required to teach a portion of the training that was developed. Students were given the option of videotaping their teaching session or conducting the training live on campus. Three students chose to teach live on campus with the remainder of the class submitting videotapes.

The instructors provided timely and constant feedback to each student via e-mail and as necessary by telephone. The feedback acknowledged demonstration of mastery or detailed specific improvements needed to the student's input to demonstrate mastery. Additional feedback and coaching were provided via telephone and face-to-face meetings based on student requests. The individual project constituted 50 percent of the students' final grade.

Strategy 6: Evaluate Student Mastery of Course Learning Objectives

Mager (1997) noted that learning objectives are "intended to let others know what you intend for your students to achieve." The logical continuation of that thought is that the instructor must measure if the students achieved what was intended. Obviously, learning objectives that are clear, measurable, and observable lead to more precise evaluation of student mastery. The authors define "mastery" as either competent to expert performance of a skill or competent to expert use of specific knowledge. As noted earlier, students in QA 6630 were required to provide written documentation to demonstrate mastery of the course learning objectives. The instructors established multiple milestones throughout the team and individual projects to assess student mastery and provide timely and constant feedback to students.

Evaluation of Course Effectiveness and Lessons Learned

The effectiveness of QA 6630, *Technical Training Methods*, offered on-line during Summer Semester 2003 was evaluated as follows:

- Informal student feedback was provided via e-mail at the conclusion of the semester.
- The authors conducted an informal critique of the course syllabus, grading protocols, chat rooms protocols, and peer evaluation protocols at the conclusion of the semester.
- Two consultants conducted a formal evaluation of the course under the auspices of Southern Poly's Extended University approximately one month after the conclusion of the semester.
- Student feedback and comments were collected approximately three months after the conclusion of the semester. (At this writing, the analysis and conclusion are not complete.)

Based the results of the first three sources, the following lessons learned were identified:

- The course learning objectives were evaluated as if they were of equal value. In fact, some course learning objectives are more difficult, more time consuming, and more important than others. Each learning objective needed to be assigned an individual point value based on difficulty and importance.
- The team and individual projects were graded in aggregate rather than by individual course learning objective. A more detailed explanation of a grading protocol based on point values for each objective was needed in the syllabus.
- The course was not based on a web-based support system such as WebCT. The course needed to be transformed into a WebCT Vista platform.
- The concept of peer evaluation for participation and contribution to team project was not included in the syllabus. A detailed explanation of peer evaluation and the impact on student grades for the team project was needed.
- Chat rooms were used as coaching/feedback sessions on team and individual projects. Reading assignments were not discussed unless students asked a specific question. Students needed a discussion tool to complete group assignments, promote collaboration, and discuss content. A discussion tool was also needed for instructors to communicate with students.
- The course did not have any links to resources available on the Internet or through the University System of Georgia libraries. Links to these resources were needed.

Additional lessons learned will be added to the above list when the conclusions from the three-month evaluation are available. Prior to the next on-line offering, the course will be transformed to a WebCT Vista platform with the other lessons learned incorporated.

References

Allen, I. Elaine and Seaman, Jeff (2003), *Sizing the Opportunity: The Quality and Extent of Online Education in the United States, 2002 and 2003*, Sloan Center for Online Education At Olin and Babson Colleges, Needham and Wellesley, Massachusetts.

Alley, Lee R. (2001) "What Makes a Good Online Course?",http://www.convergemag.com/magazine/index.phtml?=11:2001, *Converge* Magazine, Folsom, California

Boser, Ulrich (October 20, 2003) "E-Learning—Working on What Works Best," *U. S. News and World Report*, U. S. News and World Report, New York

Handbook and Tools for Distance Education Instructors, (2002) http://www.iddl.vt.edu/handbook, The Institute for Distance and Distributed Learning, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Hootstien, Ed (2002) "Wearing Four Pairs of Shoes: The Roles of E-Learning Facilitators", http://www.learningcircuits.org/2002/oct2002/elearn.html, American Society for Training and Development, Washington, District of Columbia.

Mager, Robert F. (1997) *Preparing Instructional Objectives*, CEP Press, Atlanta, Georgia

Montgomery, Damon G. (2000) "Statistical Analysis of MSQA Course Grades," Master's Thesis, Southern Polytechnic State University, Marietta, Georgia.

Roby, Teshia Y. (2002) "An Exploration of Perceived Successful and Unsuccessful Peer Collaboration Exercises within Online University Courses," Doctoral Dissertation, Georgia State University, Atlanta, Georgia.

VanNess, Shawna (2003) "A Revolution in Distance Learning," *Newsday*, Newsday, Inc., New York.

Willis, Barry (1994) *Distance Education-Strategies and Tools*, Educational Technology Publications, Inc. Englewood Cliffs, New Jersey.

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