Using On-Line Technologies in Science Education

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Abstract

Distributed education has come of age with multiple synchronous and asynchronous on-line technologies. The presenter, a veteran science educator, plunged into this new teaching environment in 2001-2002, teaching several wholly online undergraduate science content courses. From this experience, a hybrid "technology-enhanced" science education course was designed and taught in 2003. Experience with the new technologies of online instruction led to some surprises and a change of opinion about the future of this growing method of course delivery.

> "The potential use of distance education within all disciplines is tremendous as this application to higher education evolves within our culture." (ERIC Clearinghouse on Teaching and Teacher Education 1999, 2)

Introduction

The ERIC Digest entitled "Effective Teaching in Distance Education" concludes with a statement, quoted above, that I have come to see as an understatement. However, my opinion was different only a couple of years ago. I believed that nothing could ever equal face-to-face teaching as a method of course delivery. I felt online education had a role but that some institutions were using it as a cash cow and students just as an easy way to get a diploma, an up-grade perhaps from a mail-order degree. But experience has led me to reevaluate that view. Now I recognize that computer-mediated environments can be very effective in facilitating student knowledge construction. The access to information and multiple perspectives this medium provides make learning possible in new ways. Students themselves cite the ability to get "information when you want/need it" as a strength of online learning (Jensen 2000), which I have seen repeated over and over in my online course student evaluations.

My jump into the virtual teaching-learning environment

During the 2001-2002 academic year, a period of job transition for me, I taught several online undergraduate-level science courses (biology and environmental science) at two different for-profit higher education institutions, both of which deliver degree programs entirely online: Kaplan College, based in Iowa, and American Military University (AMU)

based in Virginia. I had no previous training and started out being very skeptical of what was possible in science education in a completely computer-mediated learning environment, but I decided to put my biases aside, at least temporarily, and give online teaching a try. I was provided syllabus guidelines and sample syllabi, as well as online support in terms of tips and other resources. Course delivery in both cases was to be entirely online and through each institution's unique web-based interface.

That year I taught five sections of introductory biology for AMU, with section enrollments ranging from 8 to 22 students. The AMU interface did not have a synchronous instructional feature, only asynchronous technologies such as email, drop box, online quizzes and exams, and web-based lessons and resources that students could download. Threaded discussion was possible as the interface had a message board, but at the time my classes started I had not learned to use that feature. The classes carried three semester hours of credit and ran for 15 weeks, as in a traditional semester model. Instruction was centered on a textbook (for this course, Starr 2002). I selected chapters for students to read and created questions for them respond to in assignments. Lessons were designed to be delivered one per week and students had to deposit their weekly assignments as a WORD file in the online drop box found through the AMU interface.

For a number of the assignments I required students to do drawings from nature or from models. This is a typical requirement in an introductory biology course but many students found it to be challenging. In the end, there were several ways students managed to meet the requirement, from scanning to taking digital photos. In the first courses the students also had to do a traditional biology term paper. In subsequent iterations, I allowed students to choose creative projects as well. They could choose the traditional assignment or could author such things as multimedia or PowerPoint presentations or a children's non-fiction book on a biology topic.

In addition to the AMU biology courses, that same year I taught an online undergraduate course in environmental science for Kaplan College. My class enrolled 23 students. The Kaplan course also centered on a textbook, in this case, Cunningham and Cunningham 2002. I found this 10-week course more taxing than the AMU courses. Kaplan's web interface was very different from AMU's and Kaplan's course format was structurally more rigid. As the instructor, I had scant input into the course content and little control over the

method of delivery. The Kaplan course had eight major lessons, another week in the middle was a catch-up week and the last was for the online exam. The Kaplan course used more online technologies than were available at AMU. There was, for example, a one-hour synchronous weekly online "seminar" using the chat function. The "discussion" got archived and statistics on it were available instantly, including the number of statements and their average length for each student. The course protocol required that I read the transcript and grade each student's contribution.

The Kaplan course also had other teaching-learning methods: students submitted small-scale projects, completed "web field trips" and responded to discussion questions via an online message board. Students were required to interact with each other asynchronously by responding to each other's message board postings. Both the AMU and Kaplan courses included online exams and student assignments that involved web-based inquiries – such as having students locate and interpret data, maps, graphs or whole research studies found on particular web sites.

The Kaplan course was based upon a structural template used for all their online courses. I was responsible for grading students weekly on assignments that included the online seminar, a short quiz, and various weekly assignments, so that a student would receive four or more grades per week. These grades were to be posted on an online Excel-like data sheet, and the preset weightings for assignments would be calculated with each entry so that students could get frequent up-dates on their class performance. I imagine this level of "feedback" was appreciated by some of the students, but it was very demanding of the instructor. One saving feature was the 5th week break for catching up, but the two four-week stretches were very time consuming in terms of grading – and all of it on the computer.

What's more, for Kaplan, each week I had to maintain "online office hours" via AOL Instant Messenger. Students would enter a chat room to ask questions or just to get more personally acquainted with the professor. I might have required students to "visit" during office hours but I found that several students "stopped in" regularly, shared their stories and got their questions answered. Overall, the technologies, or tools, of on-line teaching that I used in these courses included:

- the "drop box" for students to deliver their assignments

- the message board (also called a discussion board) for student-teacher and student-student communication on a topic – the technology used in a "threaded discussion"
- on-line seminars via a "chat room" technology
- email listserv to deliver "professor notes," images, diagrams, etc.
- web-posted PowerPoint presentations (later I learned how to put up video clips, and sound files for students to access through their browser)
- online office hours
- online quizzes and exams.

To me, the most interesting new teaching tool that I experienced was the online seminar, or "chat session." The Kaplan chat interface automatically gathered all sorts of data during the seminar – including attendance and how many times and for how long each student (and myself) "spoke." This data was delivered to me after the session to be figured into my grades. Any student who missed a seminar for a valid reason was to have a make up assignment related to the seminar topic. This was another assignment to create for each week and one more grade that had to be kept track of by the instructor.

With twenty-some students in chat each week the seminar sessions were, to me, somewhat chaotic, and only marginally worthwhile. I came prepared with questions to post but found it difficult to track and respond to the multiple conversations that inevitably erupted with so many participants. This year in my work at the University of Tennessee, I have used chat more effectively with smaller classes. In larger classes I have formed groups of 4-5 for weekly chat interaction, which is another way of making this technology more productive for real communication.

In terms of my preconceptions, what surprised me most was that students' personalities and learning strengths and weaknesses could indeed be perceived at a distance through their writing, photos and discussion board postings. I was surprised to see in my course evaluations that so many reported that they learned a lot, and I was chagrined to receive numerous compliments as an online instructor.

In the later iterations of the AMU biology course (their 15 week semesters overlapped), I revised the syllabus to develop better questions and assignments. I designed assignments that required students to describe local problems or issues that related to the course content being

studied. I also created an assignment called a "self-guided field trip" so that students would experience something of the living world in their own local environment and reflect on that in terms of the course content. I used this assignment to begin the course:

> Visit a natural area near your present location, such as a nature preserve or a large park with a nature trail. Spend some time hiking and observing or "Seton Watching" – sitting at an observing post in a natural setting. Your observing session should be at least half an hour. Identify the place and the date and time span of your visit. Make a list of the living things you observed and the state of their being (for example, active, or dormant). Write down two or three things you wonder about as you observe. Optional: sketch an association of three or more organisms (plant, animal, fungus, etc. – can be a close up view or a view at a distance).

In later iterations of the course I also added more assignment options, for example students could illustrate weekly assignments with graphics or illustrations, submitting them as gif or jpg files, or importing them into WORD files. Here is another example of a weekly assignment intended to connect students to their local environments, this one in the botany unit of the biology course:

> Locate a plant in flower or obtain a flower from a florist or garden center. Study the flower blossom of the plant. Identify your plant and describe the flower and its characteristics (shape, color, fragrance, etc.). Take your flower apart and notice the parts and how they are connected.

I was surprised that several students simply had no access to flowers, as they were taking this course from military outposts such as Bosnia and Afghanistan. One of the amazing things about the AMU students was they were taking the course from such far-flung locations. I had students logging in from all over the world (a problem for a synchronous function, like chat, which wasn't available in the AMU interface anyway). For many of these military personnel, an online course such as the one I taught was the only educational option other than self-teaching through books (and books may have been harder to come by for them than internet access).

Here is an example of an assignment in the Kaplan environmental science course that was also designed to connect students to their particular locales:

> In this project you will examine up close a real parcel of nature somewhere within the area where you work or reside. Locate a natural area, preferably one with one or more marked trails that you have never visited or have not visited for at least ten (10) years. If such a place does not come immediately to your mind, you can find out about accessible natural areas in your area by contacting your local department of parks and recreation. Alternatively, seek information about nature preserves and parks in your area on the Internet. Look for this information on the websites of your state's park or forestry agencies or those of the local chamber of commerce or tourism bureau, or look for Nature Conservancy preserves on the Nature Conservancy website, which has state links (http://nature.org). Once you have decided the site for your field trip, plan your visit (some Nature Conservancy tracts require permission). Aids for "seeing" include a pair of binoculars, a magnifying lens, and a camera. Plan to take a sketchpad and pencil or a camera so that you can draw or photograph a scene from your field trip involving the relationship of three or more organisms (plants or plants and animals or plants and fungi). This might be a relationship between large organisms such as trees or small organisms observed through a magnifying lens. Your drawing or photograph can later be scanned and exported in gif or jpeg (jpg) format and then incorporated into the report you write about your field trip.

For this assignment I received image files created in a number of ways, and some students reported that they had had to learn to use a scanner or digital camera that they had borrowed to do the assignment.

Another type of assignment that I found to be effective as a teaching method was the web-based inquiry. Some of these were more involved than others. Here is an example of a very simple web-based assignment that was used in the introductory biology course: "Do a web search on any of the themes or concepts in this week's ecology lesson – for example, population growth, pollution, air quality, status of the environment, etc. Write a paragraph about your most interesting findings. List the URLs."

Students seemed to get a lot out of their web inquiries. Some students remarked about finding particular sites interesting, others said a particular site sparked their curiosity, such as, "I had no idea about this and now I want to know more." Further, I was surprised that many students extended their searches beyond than what I had required in the assignment. Here is an excerpt of a response from a Kaplan environmental science student:

> I felt this was one of the more difficult web field trips. The web sites were informational, but I thought they were too technical, so I also went to other websites to understand a little better. I couldn't get into anything in www.who.int/whosis - it kept telling me it was busy. However I did get most of my information from www.who.int/health-topics/idindex.htm.

Overall, student feedback in the online science courses was positive. Many reported that the self-guided field trip was a highlight of the course. For example, several said they had never been to the particular natural area they chose, though it was accessible to where they live. One student sent me an email that stated, “I want to take this opportunity to thank you, again, for a wonderful class. I've thoroughly enjoyed the Kaplan experience and Environmental Sciences in particular. Lesson 6 (the self-guided field trip) will stand out in my memory for a long time.” Another wrote, “I would have to say that this was an extremely fulfilling experience that I was fortunate enough to be able to get bits and pieces of it captured on our digital camera. This experience has given me hands-on proof that nothing is always, as it seems. You have to look at things with an open mind.” Two others stated: “I really enjoyed myself on this field trip and would happily do it again, matter of fact I have started to walk here because its so peaceful,” and, “I would like to thank you for the opportunity to take this trip. My kids and I really enjoyed ourselves.”

A Scholar’s Perspective

Christopher Dede, the Timothy E. Wirth Professor in Learning Technologies at Harvard University, describes the facilitation of distributed learning as "orchestrating educational activities among classrooms, workplaces, homes, and community settings" (Dede 2000, 187). Dede speaks of “distributed education across time, space, and media” (with the term “distributed education” preferred over “distance education”). He also speaks of these online teaching technologies as “representational containers” and summarizes the results of his research as“Beyond McLuhan” (who is noted for having said that the medium is the message):

- media shape their messages
- media shape their participants
- infrastructures shape civilization” (Dede 2003)

That is, “the integration of interactive media into learning experiences profoundly shapes students’ educational experiences.” Dede emphasizes that “face-to-face instruction” is but one of many teaching methods that we should be using to reach our students. Some of the others that he discusses are new to me, such as MUVEs (multi-user virtual environments), a technology that uses digitized museum resources and that involves the user or student in

creating and using an avatar, or virtual persona). “Tapped In” is a MUVE developed for the professional development of educators (http://www.tappedin.org). In teaching using this technology, Dede assigns students to small groups that meet in a virtual conference center “inside” Tapped In, which provides a virtual context and avatars used to explore digital artifacts.

Another groupware tool new to me is called Groove (http://www.groove.net). This is a team-based learning environment for small groups to work together on a shared document. They can brainstorm on a white board, examine websites, and talk in real time with each other, either through text or via microphones and headsets. Dede has groups create an artifact (such as a collaborative story or a design for a school) within their common virtual work-space. A similar technology is NetMeeting (http://www.microsoft.com/windows/netmeeting/).

Dede uses many such methods/technologies in his own classes, and at the end of his courses he asks students to rate the methods used in order of preference and impact on their own learning. He claims that over many years these polls have indicated that “face-to-face” rarely is selected the first choice by students (but usually is the second choice). He states:

> Distributed learning is not traditional distance education, but instead involves educational experiences that combine the use of face-to-face teaching with synchronous and asynchronous mediated interaction. This instructional strategy distributes learning across a variety of geographic settings, across time, and across various interactive media. For example, in our MUVE, students alternate classroom discussions with simulated virtual experiences that can include remote participants. A variety of studies indicate that distributed learning adds important dimensions to face-to-face instruction, enabling some learners who might be silent in classroom settings to “find their voices.” (Dede 2003)

Dede’s website at Harvard provides many links to his research and information about some of these cutting age teaching-learning tools (see <http://www.gse.harvard.edu/~dedech/502/>).

Taking Science Teacher Education Online

Based on my experience with the AMU and Kaplan courses, I redesigned one of my regular classes at the University of Tennessee (UT) into a “technology-enhanced” science education course that includes both on-line elements and face-to-face components. The course, “SciEd 565: Issues and Trends in Science Education” debuted in the summer of 2003 as the

first hybrid online science education course offered at this institution. As a summer course it was compressed into a more intense 8-week version. I was surprised that 16 students registered for the class – many *because* it was an online class. I was further surprised that 4 of the students who enrolled did not own computers or have computers in their homes, but these 4 were willing and able to get to computers and the internet in their local public libraries.

UT uses Blackboard 6 as its interface for online class activities, a different interface from those at AMU and Kaplan but with similar features. I integrated many of the technologies available on Blackboard into my online science education class – announcement board, drop box, online seminar (chat), threaded discussion (message board), posted documents for student download (syllabus, assignments, articles, handouts and overheads), and email listserv.

The online course was a new experience for my UT grad students. While all were email users, none of them had ever taken an online course and half had never used the Blackboard technologies, while five had never experienced internet chat. Sixteen students together for the online chat turned out to be too many for coherent and focused student-teacher communication, but the chat function worked very well for small group communication, The four groups of 4 worked on group projects and met in chat session for an hour each week.

Because of the value of the self-guided field trip assignment in the earlier online science classes, I adapted that assignment to SciEd 565, relating it now to one of the trends in science education, the growth of agencies of informal education, such as science museums, nature centers, technology centers, zoos, and so forth. Technology use was enhanced further by requiring photographs and an investigation protocol was included that specified correlating exhibit/program content with national or state standards. Here is the assignment:

> **THE TASK:** This assignment can be accomplished in teams of two. Begin by selecting an agency to visit and finding out its hours of operation. You should try to visit an institution new to you or one not visited for at least five years. Plan to spend 2-3 hours minimum and to have materials for taking notes, and, if available, a digital camera (however, you can have regular photos scanned). Call ahead and arrange to speak to a staff member in the agency's education department. Ask for brochures and materials about the agency's K-12 programs for school groups. Examine these materials in preparing your report. During your actual on-site visit, first take a "survey walk" through the entire exhibit area in order to get an overview of the content and overall presentation. Then go back to two or three exhibits you would like to scrutinize in more depth. In examining these exhibits, note the content for later comparison to the NSES or Tennessee Framework for grade level appropriateness. Note the quality of exhibit labels in terms of reading levels, length, readability, clarity, accuracy, etc. Observe how

other visitors, especially children, interact with the exhibits and/or programs. Take pictures if allowed. In your meeting with an education staff person, ask about procedures for working with school groups. Ask about agency programs both on-site and off-site ("outreach" in schools). Ask about resources made available to teachers. Ask about agency accreditation and program evaluation and future goals.

Your written report should:

- identify and describe the agency of informal science education you visited, the dates and times you were there, the name of your contact in the education department, how you went about your visit, and one or more images that illustrate your visit;
- summarize the science content and level of the exhibits and outreach programs and indicate connections with the Tennessee Science Framework or NSES;
- speculate on how students (intended audience) might respond to the exhibits/programs;
- provide a critique (appreciations and criticisms) of exhibits, programs, performance of personnel, and,
- recommend improvements re. the agency exhibits and school programs.

Another assignment for SciEd 565 was a series of "web quests," defined as "a virtual field trip, a customized, guided investigation to be completed online." Here is how they were presented:

Web Quest 1: Identifying educational stances in the professional community.
The Task: URLs for the web sites for organizations such as the NEA, AFT, and PDK, as well as organizations specific to science and environmental education, such as NSTA, SSMA, and NAAEE are provided in the syllabus. Other organization sites include:

- ASCD – Association for Supervision and Curriculum Development http://www.ascd.org/
- AASA – American Association of School Administrators http://www.aasa.org/
- NAESP – National Association of Elementary School Principals http://www.naesp.org/
- Phi Delta Kappa http://www.pdkintl.org/
- National Association for the Education of Young Children http://www.naeyc.org/
- National PTA http://www.pta.org/

Visit and explore the web sites of at least four (4) organizations, including at least one general organization or agency and one specifically oriented to science education or EE. Look for position statements related to pedagogy or on educational issues. Identify and describe particular stances taken by the organizations you have picked. Compare stances among the four organizations. Do you find agreement/disagreement on any issues?

Web Quest 2: Innovative, Exemplary, and Model Science Programs.

The task: Search the web for new and model science programs across the US and internationally. Your instructor was instrumental in the establishment of Community High School in Roanoke, VA (www.communityhigh.net). You may find useful information on this topic at these URLs:

- the Annenberg Guide to Math and Science Reform with its links to model programs: http://www.learner.org/k12/The_Guide/
- the Education Resource Information Center Clearinghouse for Science, Mathematics, and Environmental Education (ERIC CSMEE): http://www.ericse.org

Describe what you think represents an exemplary science program at either the elementary, secondary, or tertiary level. Justify your choices.

Web Quest 3: Multiculturalism, Antiracism, and Science Education.

What does multiculturalism and anti-racism mean for science education, i.e., what does "correct" practice look like in the classroom and lab? What objections have been raised to multicultural/anti-racist approaches?

The task: Read the essay, "Liberalism, Multiculturalism, and Education: Is There a Fit? by Stacy Smith of Cornell University, on the Philosophy of Education Society website, at http://www.ed.uiuc.edu/EPS/PES-yearbook/95_docs/smith.html (also see the response by Richard Brosio of Ball State University, linked to Smith's essay). Next, read the essay by Harry Dhand of the University of Saskatchewan entitled "Implications of Multiculturalism for Education: The Canadian Context, found at http://www.ncert.nic.in/ncert/journal/journalnew/iechap5.htm)

Next, read the essay by Hal Dyck, "The Effects of Multiculturalism on Education (http://instructordiploma.com/core/102 B/hal.htm. Your last task is to use Google or other search engines to look for informative sites on the net addressing multiculturalism in science education. Describe the contents of two or more of your best finds.

From student feedback, the self-guided field trips and web quests were effective assignments in terms of learning value. Overall, the student evaluations for the course were positive – most negative comments had to do with "too much work/too many assignments." Following are comments that were on student SciEd 565 course evaluations:

"I thought the group discussions and small groups were best."

"I really liked the online discussion board, small group chats and references, bibliographies provided."

(What aspects of this detracted from your learning?) "Having to meet on campus – would've been better if all of classes had been online."

"Great class, keep it and be sure it is taught regularly."

"Class was great! First on-line experience in a class – I thought it was fun/useful."

"There was a lot of reading, would have been easier in fall or spring."

Conclusion

I was skeptical about the value of distributive education when I took the plunge into online teaching in 2001-2002, but I gained new skills from the experience and it changed my thinking about computer-mediated distance education. I still believe that face-to-face instruction in the classroom is best for some things and should be part of the mix of any higher education program design. Face-to-face still shines in building student to student and teacher to student rapport, but it is also not the only way to achieve that goal. All in all, I have come to believe that tertiary courses can be greatly enhanced through appropriate use of the many new instructional technologies available for distributive education.

References

Cunningham, William P. and Mary A. Cunningham. 2002. *Principles of environmental science: Inquiry and applications*. Boston: McGraw Hill.

Dede, Christopher. 2003. Future technologies for teaching and learning. Paper presented at the annual meeting of the Association for the Education of Teachers in Science, Jacksonville, FL.

Dede, Christopher. 2000. *Implications of emerging information technologies for education policies* [online]. Boston: Harvard University [cited February 25, 2003]. Available from the World Wide Web: <http://www.hpcnet.org/upload/wbec/Dedetest.pdf>

ERIC Clearinghouse on Teaching and Teacher Education. 1999. Effective teaching in Distance Education. (ERIC Digest EDO-SP-1999-5).

Jensen, Richard. 2000. *Using asynchronous network courses to bridge gaps in the teeth of a university curriculum with imported gold: Bridgework may be optimally effective only by incurring higher labor expenses*. Hartford, CN: Trinity College [cited February 25, 2003]. Available: <http://www.trinity.edu/~rjensen/255wp.htm>

Starr, Ceci. 2002. *Biology: Concepts and applications*, 5th ed. Pacific Grove, CA: Brooks/Cole, Thomson Learning. (Note: Students also had access to practice quiz questions, hypercontents, and "BioUpdates" – current events - via the publisher's support site on the web at <http://www.brookscole.com/biology>.)