Back to the Future of Educational Technology

by

Fred T. Hofstetter
University of Delaware
July 2, 2007

Prelude

Each year under its Pfeiffer imprint, John Wiley publishes a series of "annuals" that document the state of the art in various fields. In 2008, Pfeiffer will begin publishing an e-Learning Annual that is being edited by Dr. Michael Allen, the inventor of Authorware, founder of Macromedia, and creator of Allen Interactions. In the inaugural issue, Dr. Allen is featuring a series of articles written by the so-called "pioneers" of the field. We pioneers have been asked to provide perspectives on how our work began, what were our hopes, what risks did we take, what did technology mean for the student, and what lessons did we learn. Printed below is the article I submitted in response to Dr. Allen's questions. This article will appear in Allen, M.A. (Ed.). *Michael Allen's 2008 e-Learning Annual*. San Francisco, CA: Pfeiffer. Copyright © 2008 by John Wiley & Sons, Inc.

Abstract

In the 1970s, we developed e-learning materials on computer terminals connected to an expensive mainframe that delivered courseware to students. To save costs in the 1980s, we moved these materials to standalone microcomputers and thereby lost connectivity. This was not a great loss for students, however, because most of us had been using the communication features to manage the development of the courseware rather than to engage students in dialog online. The science of learning had only just begun to create the design principles that would guide effective use of the network. In the 1990s the popularity of the World Wide Web created the critical mass that led to the Internet becoming the global information utility that powers the 21st century. Having regained the connectivity we had lost, we are kind of back to the future. As it always does, however, the future changes before it gets here. In this case, the science of learning evolved principles that altered our perception of how the network should be used in the design of effective learning environments. This article chronicles the technological context in which the principles evolved, reflects on lessons learned from 35 years of practice, and discusses implications for further work.

Where Did We Begin?

My work with educational technology began when I was hired as a music instructor at the University of Delaware in 1973. My assignment was to teach ear-training, which is a demanding two-year course that every music student must pass in order to remain enrolled in a college music program. The problem with teaching ear-training is the wide range of individual differences among college music students. Some students are naturally gifted at rhythm, while others are more talented in pitch perception. Singers with beautifully resonant voices may stumble when trying to vocalize a notated melody. Some students who excel at melodic intervals confuse them when the intervals combine to form chords and harmonies.

Bloom's Mastery Learning Model

At the time I was facing this dilemma, Bloom's (1968) learning for mastery (LFM) model was coming into vogue. According to this model, students progress through graded units of instruction and are not permitted to go to the next level until mastering the current level. A meta-analysis conducted by Kulik, Kulik, and Bangert-Downs (1990) found that LFM increases test results by 0.59 standard deviations across a broad range of subjects including mathematics, reading, science, and social studies.

As Saettler (2004) notes, Bloom's mastery learning model does not work with all forms of instruction, but it is highly applicable if the subject domain is algorithmic, hierarchical, or procedural. Because music is highly procedural, I decided to design a mastery learning system for ear-training. I named the system GUIDO in honor of Guido d'Arezzo, the 11th century monk who invented the musical staff.

Graded Units for Interactive Dictation Operations

GUIDO stands for Graded Units for Interactive Dictation Operations. Following Bloom's mastery learning model, GUIDO presented a graded series of musical dictation units in the domains of intervals, melodies, chord qualities, harmonies, and rhythms. In each domain, the student began with the first unit and practiced at that level until attaining the score needed to advance to the next unit. Bright students progressed quickly through the units, while slower students got extra practice. Because the program was new and I did not know exactly how to sequence the units or how difficult to make them, I based GUIDO on a table-driven design in which all of the instructional variables were put in a table that the instructor could edit. Through this table, the instructor could make the course more or less difficult, adjust the content and sequencing of the units, or even create new units of instruction.

Analysis of Student Response Matrices

Through controlled experiments, we found that students who used GUIDO scored significantly higher on ear-training examinations than students in control groups using traditional methods of instruction. A series of articles published in the *Journal of Research in Music Education* (Hofstetter 1975, 1978, 1979, 1980) documented the learning gains. These articles further described how GUIDO kept response matrices of all the questions asked and responses given. By analyzing these matrices, we discovered perceptual patterns that changed the thinking about music theoretical concepts that had been misunderstood for hundreds of years. We found melodic and harmonic situations in which students were not just getting answers wrong, but were also agreeing on what the wrong answer was. The music community was highly interested in this research, and I was invited to present my work at many colleges and universities. In 1975, Dean Helen Gouldner provided a startup grant that enabled us to begin the National Consortium for Computer-Based Music Instruction (Hofstetter, 1976) which continues today as the Association for Technology in Music Instruction (ATMI). The significance of this work helped me earn tenure at UD, where I continue to be a faculty member at one of the finest universities in the world.

What Were Our Hopes?

Compared to computers today, technology was in a primitive state in the 1970s. I began my work with GUIDO, for example, on Tektronix display terminals that were not selectively erasable. If you wanted to erase anything onscreen, you had to erase the entire display. Imagine designing e-learning modules under such a constraint!

Acquiring a Delivery System

We needed a better platform, so we explored alternative systems. The National Science Foundation had invested heavily in two high-profile projects called PLATO and TICCIT. The PLATO terminals had plasma panels that were selectively erasable and transparent. You could rear project micofiche slides onto the plasma panel, upon which the computer overlaid text and computer graphics. PLATO also had a computer-controlled random-access audio device that could play audio clips from a 15-inch magnetic disk. In order to obtain the speed of access needed to display slides and begin audio playback promptly, the microfiche and audio devices were powered by compressed air. Even though the technology was primitive, we felt PLATO provided more versatility than TICCIT, which relied on a central bank of computer-controlled videotape players that was staff intensive and not very portable.

PLATO was expensive, however. The terminals pictured in Figure 1 cost $6,000 each and needed to be connected via leased telephone lines to the PLATO mainframe at the University of Illinois, where PLATO was invented. The long-distance communication costs were prohibitive. The only way for us to bring down the cost was to develop the critical mass of interest needed for UD to be able to justify purchasing and installing its own PLATO mainframe. Control Data Corporation (CDC) manufactured the Cyber mainframe computer that powered PLATO. In 1976, CDC acquired the rights to market PLATO. Our goal became achieving the critical mass of interest needed for UD to purchase a PLATO mainframe.

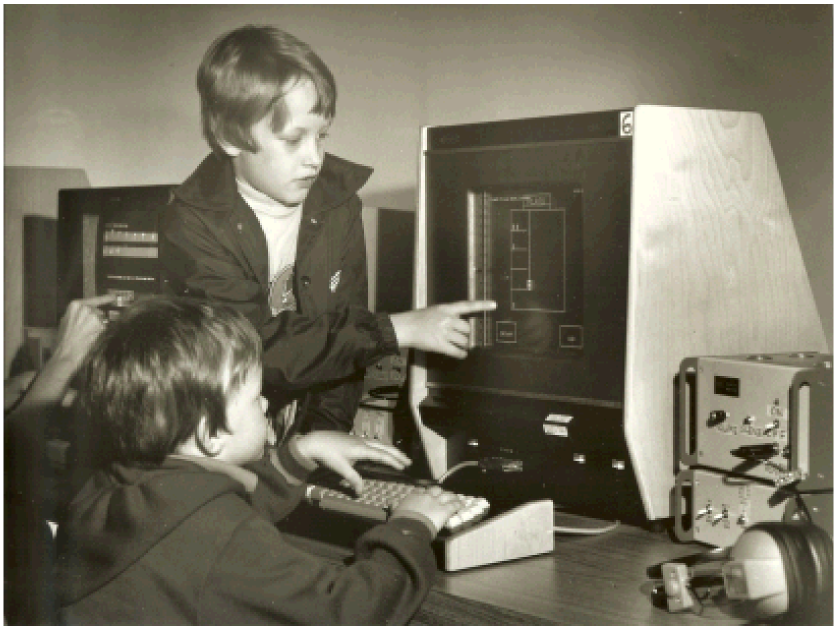

Figure 1. The author's sons Dan (standing) and Tom (seated) use a PLATO plasma display terminal in 1979. In the background, a student is touching the screen to place a musical note onto the staff of a GUIDO melodic dictation exercise.

Achieving Critical Mass

My friend, colleague, and mentor L. Leon Campbell, who was UD's Provost throughout this period, explained that in order to justify the purchase of the multi million-dollar mainframe, I would have to show widespread faculty interest in using PLATO across the campus. Thus began the Delaware PLATO Project, which lasted for fifteen years from 1974-89. I became the Delaware apostle of PLATO and gave demonstrations for faculty all across campus. Based on effective results from pilot projects in 36 academic departments, we were able to convince Provost Campbell to purchase a PLATO mainframe, which was installed in the UD computing center in 1978. Our work with PLATO is documented in a series of Summative Reports in the ERIC database.

Moving Beyond Programmed Instruction

When I reflect on the broad range of applications we developed, I realize how pigeonholed the modern view of the classic PLATO system is. I say pigeonholed because most contemporary researchers who write about PLATO use it as an example of programmed instruction. Lockee, Moore, and Burton (2004, p. 563), for example, refer to PLATO as "the most prolific and long-standing example of computer-based PI." They are correct in the sense that PLATO stands for Programmed Logic for Automatic Teaching Operations, which was how most people used it. PLATO was capable of much more, however, and we were using it for more than behaviorally oriented PI. We had the PLATO system, for example, doing career counseling, demography, and psychology experiments. Our engineering college even programmed a model of the Delaware Bay that could track the movement of oil slicks in the event of a tanker spill.

What Were the Risks?

In the 1970s, attempting a large-scale computer-assisted instruction project was filled with risks. The hardware was expensive, and we needed to raise the money to pay for it. Budget-hungry deans wanted academic results. If we developed ineffective materials, the deans would argue that our budget should be spent elsewhere.

Ramping Up

In order to raise money to help UD pay these costs, we began selling PLATO services to corporations, government agencies, and school districts. Most notable among the corporations was DuPont, with whom we partnered to create a laboratory technician training program. In government, our largest customer was the Federal Aviation Administration (FAA), which used our PLATO system to teach flight inspection procedures, radar, communications equipment, and electronics. In our local school district, which was undergoing desegregation, we used an Emergency School Aid Act (ESAA) grant in 1979 to install PLATO terminals with the goal of reducing minority group isolation by providing basic skills instruction to improve student achievement, enhance student self-concepts and foster more positive interracial interactions. Under a grant from Control Data in 1981, we were funded to create the Lower Division Engineering Curriculum (LDEC).

Developing Effective Courseware

One of the greatest risks in creating a computer-aided instruction (CAI) project in the 1970s was that there would not be enough quality software available to sustain the project. As Nievergelt (1980, p. 11) expressed it, “Today it makes no sense to start a CAI project unless one is willing to write most of the necessary software.” Because courseware development was expensive and time-consuming, we needed to make sure the materials we produced hit the mark. Academic deans were watching us, and they wanted evidence that our materials were effective. We needed a mechanism for developing courseware that worked from the start. Budget-hungry deans would use any failures as reasons to reduce our funding. Figure 2 shows the courseware development process we created (Hofstetter, 1981, p. 645). It contains a variety of feedback loops, whereby we used techniques of formative evaluation to help ensure that the courseware we were developing would be effective. In a contemporary implementation of this concept, Allen (2006, p. 73) refers to this iterative process as successive approximation.

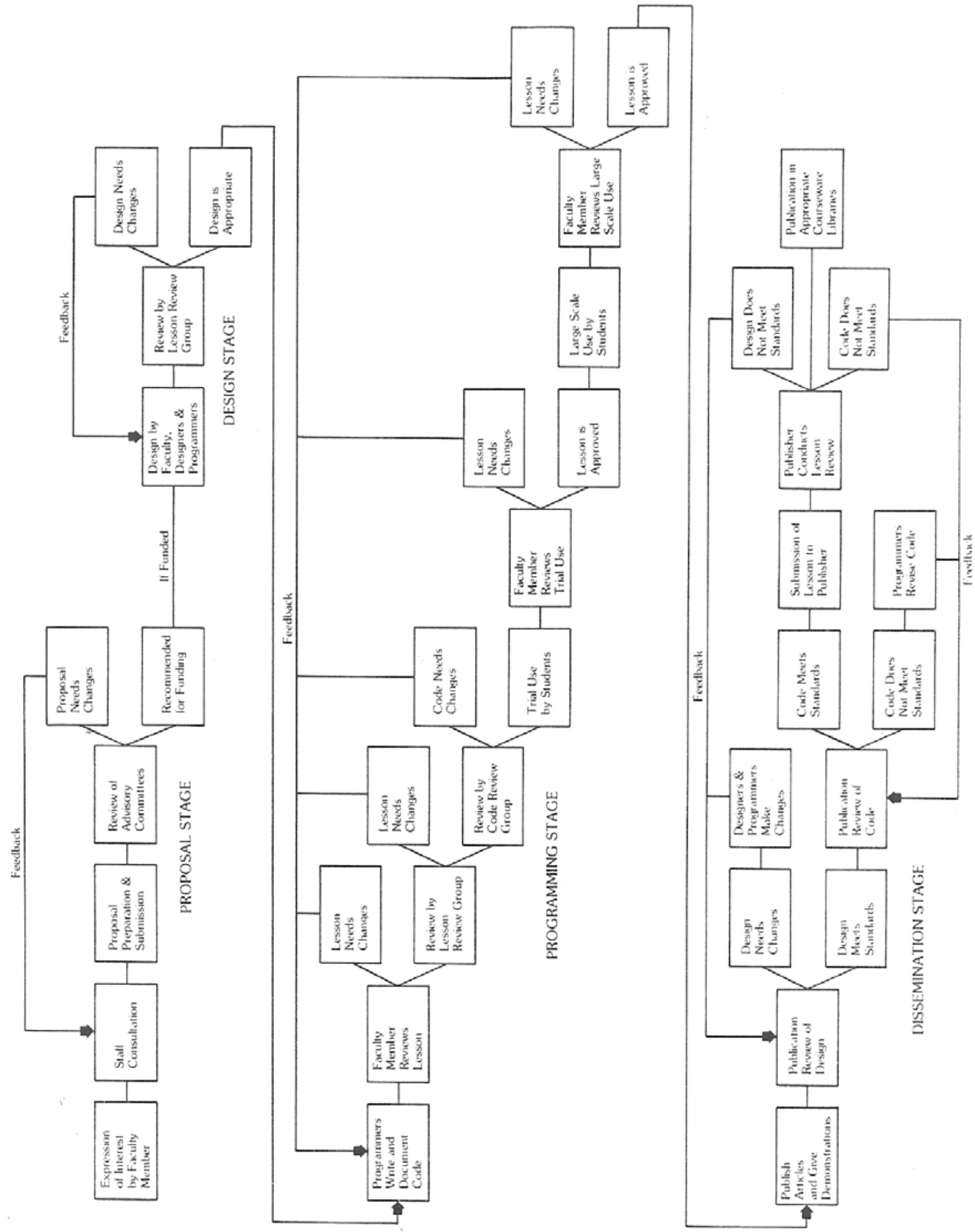

Figure 2. The Delaware Model for Courseware Development.

Scaling Back in Recession

In the 1980s, the Reagan tax cut led to an economic recession, and UD began to scrutinize every aspect of its budget. So did DuPont and the FAA, which sought lower-cost alternatives to the expensive mainframe connections. Reading the handwriting on the wall, and not wanting to lead UD into a budget shortfall, I led the effort to convert our most successful PLATO programs into a microcomputer format. At first, we converted software to micro PLATO, using microcomputers invented by Control Data Corporation. In 1985, we began using IBM PCs programmed in TenCORE, which was a standalone version of PLATO's TUTOR programming language.

In 1989, we uninstalled the PLATO mainframe when the Philadelphia Prisons decided to discontinue its 26 terminal subscriptions and begin running on IBM PCs instead. While we saved cost and avoided a budget shortfall by moving our programs from the PLATO mainframe to less expensive microcomputers, we lost the network. No longer could instructors communicate with each other through PLATO notesfiles or press "term-TALK" to initiate an online chat.

What Would Learning Technology Mean for the Student?

The loss of networking was not as devastating then as it would be today because most of us had been using the communication features to manage the development of the courseware instead of involve students in online course discussions. The pioneering work of the great Russian psychologist Lev Semyonovitch Vygotsky had not yet made it into the mainstream of American educational technology. We did not know that the most important use of the network would be to scaffold students and provide customized coaching when they encountered difficulty. Vygotsky's work was just being translated into English. Because we did not yet know it, we did not realize what we were losing when we lost connectivity. In other words, losing the network was not such a great loss in 1989, because we did not yet know what to do with it.

Skinner's Linear Behaviorism

American psychology was dominated by the behaviorists. Chief among them was Skinner (1938, 1953), who saw that human behavior is powerfully shaped by its consequences. Moreover, Skinner felt that psychology was essentially about behavior and that behavior was largely determined by its outcomes. Instructional designs were based on a stimulus-response (S→R) chain in which positive reinforcement was provided when students answered correctly. Such designs had no need for computer networking because all of the feedback was pre-programmed.

It would be several decades before American educational technologists would recognize the vital role of networking in education. As late as 1989, for example, we received an EDUCOM/NCRIPTAL Best Tutorial award for an *Introduction to Statistics* course that did not contain any communication features, neither for instructors to coach students nor for students to help one another. The IBM PC version of GUIDO won a Joe Wyatt Challenge award in 1991 without any connectivity. Toward the end of his career, Skinner himself did not foresee the vital role computer networking would play in education. As late as 1986, Skinner maintained that the microcomputer is "the ideal hardware for Programmed Instruction" and proposed that when used for computer-aided instruction it should be called a "teaching machine" instead of a computer (p. 110).

Vygotsky's Triangular Constructivism

Vygotsky (1978) provided the missing link by transforming the linear S→R model of the behaviorists into a triangle that represents how people learn through an extrinsic process in which knowledge is mediated by student interaction with tools, community, and understandings acquired through prior learning. Figure 3 shows how Vygotsky drew this triangle by adding to the stimulus-response chain a third node called X, which stands for extrinsic. This extrinsic node is bidirectional, meaning that students can reverse the action of the S→R chain by interacting with tools, instructors, experts, peers, knowledge bases, multimedia, datasets, and professional associations. Since the learner is portrayed as an active processor who explores, discovers, reflects, and constructs knowledge, the trend to teach from this perspective is known as the *constructivist* movement in education.

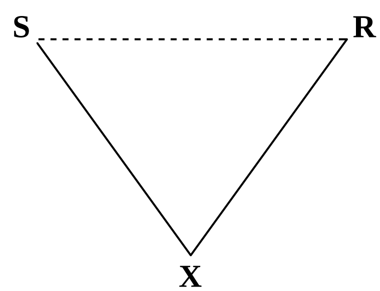

Figure 3. Vygotsky's interaction triangle. S is the stimulus, R is the response, and X is extrinsic mediation through which students learn by interacting with objects in their environment including tools, instructors, experts, peers, knowledge bases, multimedia, datasets, and professional associations.

Zone of Proximal Development

Vygotsky (1978, p. 86) observed that when students are learning, inevitably they stray into a zone in which the difficulty of the problem they are working on exceeds what they can accomplish independently. Because the zone is between the student's current level of development and the next level that could be achieved through an expert's guidance, Vygotsky called it the Zone of Proximal Development (ZPD).

Online learning creates the zone whenever students submit assignments that fail to meet the criteria for a high grade. Instead of assigning a low grade and moving on, I believe we have a responsibility to coach the students and help them achieve the objective. To create such a learner-centered environment, I invented a Web-based e-learning system called Serf (Hofstetter 1997, 1999, 2006), which has a feature called "give the student another chance." When the instructor clicks this option, a scaffolding protocol creates a just-in-time discussion forum in which the instructor provides graduated prompting according to the student's needs. At first, the instructor gives general help. If the student still stumbles, the instructor gives more specific guidance. By making the student's thinking visible, the dialog provides a record of the coaching that both student and instructor can study and reflect on how to improve. Today's behaviorists consider scaffolding to be an antecedent that plays a vital role in invoking the desired response; thus, through scaffolding, behaviorists have discovered some common ground with Vygotzky and his followers.

Activities Around the Zone

Figure 4 is an activity diagram that illustrates the manner in which I believe e-learning revolves around the zone. Following Engeström (1987, p. 78), the top three nodes of tools, subject, and assessment represent mediated activity through which the student learns to perform the outcome of the instructional goals. When the student cannot accomplish this independently, the instructor provides coaching in the zone, which is represented by the bottom inner triangle. The outer triangle has a node representing community on the bottom left, and professional organizations on the bottom right. The instructor is responsible for creating curriculum that leads to certification as defined by the appropriate standards body. The instructor's role is bidirectional in that the instructor can also provide recommendations to the professional organization regarding refinements or additions that may be needed to make the standards meet community needs.

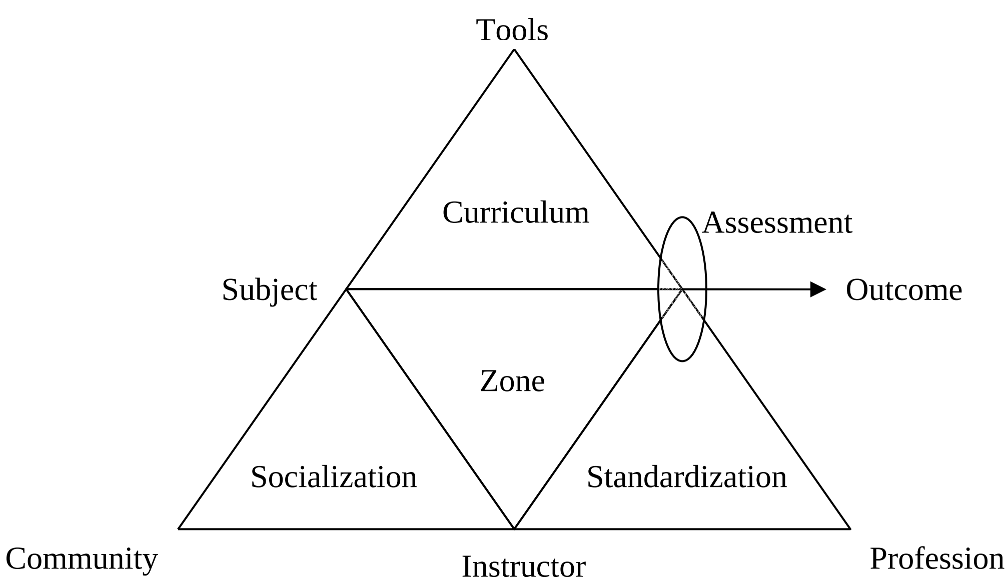

Figure 4. Activities around the zone in a socially constructed e-learning environment.

Have We Learned from the Science of Learning?

At the turn of the century, the National Research Council (2000) published a landmark book entitled *How People Learn*. It is a wonderfully written synthesis of developments in the science of learning. A fascinating chapter on brain research (Chapter 5) describes how learning makes physical changes that reorganize the brain. The manner in which these connections happen to rewire the brain reinforces three primary principles that have emerged from the science of learning. These principles are:

1. People learn by connecting new information to concepts already learned.
2. To learn how to reason, solve problems, and augment knowledge in a field of inquiry, people need to understand facts and ideas in the context of a conceptual framework that facilitates application to real-world problem solving.
3. People are motivated to learn when they can set their own goals, reflect on their progress, and feel in control of their learning.

From these principles, it follows that instructional designs should:

1. take into account the learner's preexisting understandings and correct any faulty preconceptions in order to prevent future misunderstandings;
2. enable students to study multiple examples of the concept at work in order to learn it in depth in authentic contexts; and
3. include metacognitive supports that make visible the learner's reflections and enable an instructor to provide scaffolding and guide revisions to improve student learning and reasoning.

Learning From versus Learning With

Hill, Wiley, Miller-Nelson, and Han (2004, p. 443) make the distinction between *learning from* versus *learning with* the Internet. When learning from, the student proceeds with guidance provided according to protocols determined by the instructional design. When learning with, on the other hand, students use the Internet as a tool. Hill et al. (p. 447) reviewed several studies that examined whether people can learn from the Internet without designed instruction. The overwhelming answer from these studies is no. Although it amazes me to think that people would expect the Internet by itself to produce results, I believe it is important to mention why it cannot. Because people learn by connecting new information to concepts already learned, the order in which students encounter new material is vitally important. Curriculum planning matters. Students need a course of instruction that presents materials in a logically appropriate order with enough real-world examples to cover the concepts in depth.

Fitting Course Goals to Student Goals

In my online courses, I have evolved a process whereby the students buy in to the course content by making its goals be their own. Early in the course, I give an assignment in which the students tell me why they enrolled and what they hope to get out of the course. A dialogic protocol enables me to conduct with individual students a little conversation in which I explain that my purpose is going to be to help them to master their goals. Most of the students provide a statement of competencies they hope to develop as the course progresses. I respond to these statements by explaining the manner in which the course will address the student goals. Later in the course, I use these goal statements to help the students propose term paper topics and multimedia projects through which students demonstrate the extent to which they have met the course objectives. The assignment protocol enables me to hold an online conversation that makes each student's thinking visible and records it into the course database for subsequent analysis and reflection.

Holmberg (2003) views the didactic nature of distance education as a teaching-learning conversation, in which the teacher bonds with a student by creating empathy. According to Holmberg, it is not only the frequency but also the quality of communication that is important in creating this bond. In the online environment, I believe one of the reasons why e-learning is effective is because people are doing it when they are in the mood to do so. If you think about it, normally you do not log on unless you are in a good mood. Thus, e-learning enables faculty to teach, and students to learn, when they are in the mood for it. Negotiating goals when both student and instructor are in a good mood leads to more ambitious projects with a higher quality of scaffolding.

Situated Cognition

Situated cognition is a term coined by Brown, Collins, and Duguid (1989) to describe the kind of learning that happens in environments designed to put students in real-world contexts. Technology plays an important role in enabling learners to study concepts in authentic contexts. Through interactive video, students can be put into real-life situations. A film clip of the Tacoma Narrows Bridge Collapse, for example, has become a classic example used by physics instructors to situate the teaching of wave motion and resonance. Under a grant from the National Science Foundation, Fuller, Zollman, and Campbell (1982) created a videodisc that included the film clip along with a slide bank and full motion videos of the bridge construction, its geographical setting, mathematical formulas, the influence of the wind, and standing wave experiments. I created a program called PODIUM that let the faculty show instantly any slide, motion sequence, or experiment on the Tacoma Narrows videodisc. By simply touching the screen of the IBM Infowindow display shown in Figure 5, the faculty could show students the historical background and illustrate the geophysical conditions that led to the catastrophe. Figure 6 shows how the faculty could experiment with different wind speeds and pulsing actions to recreate the standing waves that led to the bridge collapse.

Figure 7 shows the assortment of equipment used to make presentations back then. Multimedia was so expensive that you could not realistically think about giving each student a computer. Instead, the focus was on equipping each classroom with a workstation that the teacher could use in making presentations. Happily, costs have dropped to the point at which the focus now is on providing students with multimedia computers to discover knowledge in real-world contexts. At the Internet Plasma Physics Education Experience (IPPEX) Online, for example, students can run the same nuclear reactor simulation that Princeton University scientists use to determine optimal settings for tokamak fusion reactors. By manipulating the sliders that control the plasma density, heating power, and magnetic field, students can explore how these parameters interact and develop an intuitive feel for the process scientists go through in designing tokamak reactors. The IPPEX simulation is online at ippex.pppl.gov/tokamak/tokamak.htm.

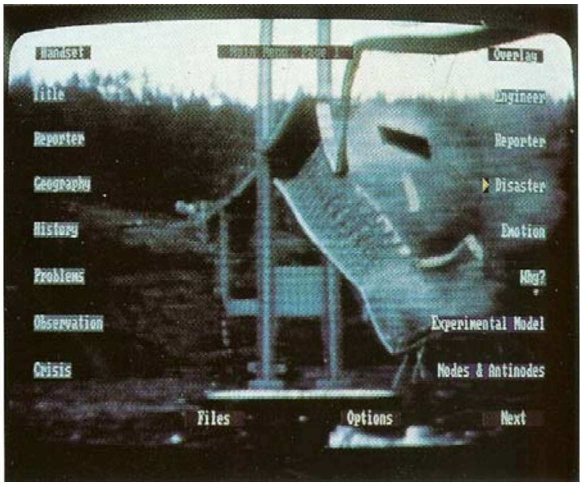

Figure 5. A PODIUM videodisc overlay for the *Puzzle of the Tacoma Narrows Bridge Collapse*.

Figure 6. Experimenting with wind speeds and pulsing actions to find the combination that created the standing wave which destroyed the Tacoma Narrows Bridge.

Figure 7. The author works with interactive videodisc in 1988.

Learning and Transfer

As Bruning, Schraw, & Ronning (1995, p. 216) explain, “The aim of teaching, from a constructivist perspective, is not so much to transmit information, but rather to encourage *knowledge formation* and development of metacognitive processes for judging, organizing, and acquiring new information.” Rumelhart (1981), following Piaget, introduced the notion of *schemata*, which are mental frameworks for comprehension that function as *scaffolding* for organizing experience. At first, the instructor provides instructional scaffolding that helps the student construct knowledge. Gradually, the instructor provides less scaffolding until the student is able to construct knowledge independently. In *How People Learn*, the National Research Council (2000, p. 53) identifies four key transfer principles that govern this process:

1. Initial learning is necessary for transfer.
2. Knowledge that is overly contextualized can reduce transfer.
3. Transfer is best viewed as an active, dynamic process.
4. All new learning involves transfer based on previous learning.

Instructional designers need to take these principles into account when choosing among behavioral, cognitive, and social constructivist approaches. Too much drill, for example, can cause negative results. In an Educational Testing Service study of the 1996 National Assessment of Educational Progress (NAEP) database, Wenglinsky (1998) found that in eighth grade mathematics, using the computer for drill and practice is negatively related to student results (-.59 grade levels), while using the computer for simulations and applications increases results (+.42 grade levels). Too much drill results in overly contextualized learning and reduces time available for problem solving and application.

Increasing Motivation

According to Allen (2003, p. 155), motivation is the most important factor in achieving success from e-learning. Allen’s law states that $e = m^2ci$, where *m* is motivation, *c* is content, *i* is interaction, and *e* is e-learning outcomes. If motivation is lacking, the *m* in Allen’s law will be zero, and therefore *e* will be zero, meaning that no learning will occur, regardless of the quality of the content and its interactivity.

Social opportunity is important in motivating people to learn (National Research Council, 2000, p. 61). To create social motivation, I have created a gallery feature, which is an option the instructor can configure for any Serf assignment. If the instructor clicks to activate the gallery, students can see each other’s submissions. Students learn a lot by viewing each other’s work, which they discuss in the online forum. Depending on the nature of the assignment, the instructor can configure the gallery to reveal the student names or keep them anonymous, and display the instructor’s feedback or keep it private. In my Web design courses I have a “cool tool” assignment in which I have the students (1) identify the tool they consider most useful and (2) write an essay explaining why they think it’s cool. Through the gallery, students explore each other’s tools and make discoveries richer than anything I could design on my own.

The innate human desire to develop competence is another factor that is important in motivating people to learn (National Research Council, 2000, p. 60). To create competence motivation, I let students choose from a selection of labs that fit a variety of school or workplace settings. Students invariably choose to do the labs that are perceived as aligning with their career path or helping accomplish tasks in their workplace.

What Are Implications for Further Work?

In setting future directions, educational technologists must consider the extent to which technology has emerged for addressing the problems we see in our current work. I believe there are three areas in which technology has evolved to the point at which we can make substantial progress in making e-learning more effective. These three areas are (1) reducing transactional distance, (2) making assessment metacognitive, and (3) creating communities of learners.

Reducing Transactional Distance

As Vygotsky (1978, p. 86) noted, learning inevitably creates a zone in which students encounter problems they cannot solve on their own. At this point, the student needs help from the instructor. In Serf, I have created a scaffolding protocol that enables the instructor to identify the zone, provide just-in-time coaching, and give the student another try. By repeating this process until the student masters the assignment, education can produce better prepared students who have truly learned the material.

The problem I have noticed in my current application of the zone, however, is that students do not know that I have provided them with feedback until the next time they log on. This creates the kind of gap that Moore (1993) refers to as transactional distance. The more time it takes the student to receive help needed from the instructor, the larger is the gap of transactional distance. It is a psychological gap created by communication latency, not a geographical gap caused by physical distance.

When I am grading final projects, for example, I often send e-mail to notify a student that I have found a problem in their submission and have provided feedback along with a chance to resubmit their assignment for a higher grade. Needless to say, students place a high value upon being given a chance to make revisions and earn a higher grade. It is time consuming, however, for the instructor to send these e-mails. I plan to automate this process by creating an option whereby students can subscribe to a notification service that will send them an e-mail automatically each time the instructor leaves them feedback on an assignment. This e-mail will include the name of the assignment, the instructor’s message, and a link to click to go to that point in the online course. In like manner, I plan to create an e-mail service whereby the instructor can choose to be notified (or not) each time a student responds to the scaffolding.

Electronic mail may not suffice, however, to reduce transactional distance for the younger generation of students who prefer to use TXT messaging on cell phones instead of e-mail on personal computers. To reach students who live on their cell phones, I plan to create a short messaging service (SMS) to which students can subscribe if they would like to be notified of course events via TXT messages that Serf will send to their cell phones.

Eventually, the cell phone interface could be extended to TXT a message whenever someone writes a response in a discussion to which the user has subscribed. I believe such a cell phone interface could substantially increase the amount of interaction in a course, especially if the student could TXT a reply back to the online discussion forum.

Making Assessment Metacognitive

One of the most important things we do in education is help students learn to reflect on whether their current level of understanding is adequate. By making the student's thinking visible, metacognitive tools enable students to reflect on their progress toward learning to think like an expert. Through conversational assignment protocols that record the dialog between students and instructors, an e-learning environment can make student thinking visible. By posing questions that make students reflect on whether their current level of understanding is adequate, the instructor can help students learn to be aware of the progress they are making toward understanding.

In my college-level courses, for example, students propose and negotiate the topics of their projects and term papers. Through an online consultation protocol, I help students create a project that not only satisfies their interests, but also meets national standards in their chosen career field. The dialog I have with my students is recorded in the course database and can be viewed at any time on the course assignment page. I encourage students to reflect on this dialog, think about their progress toward meeting the standards, and become actively involved in setting their learning priorities.

The next assignment dialog I plan to create is an ePortfolio protocol in which students will document and reflect on the extent to which they meet professional standards in their field. Instead of having students use canned software that creates the portfolio for them, I believe we should have students learn to use industry standard Web authoring software to create their own portfolios and thereby acquire strategic 21st century multimedia authoring skills. The portfolio assignment protocol I plan to create will prompt the students to provide a link to the spot in their portfolio that demonstrates the extent to which the student has met each standard. By requiring the students to have an expert review their artifacts, include the expert's comments in the portfolio, and respond to the expert by explaining what they plan to do to follow up on the expert's advice, I believe we can make the student's thinking visible in the context of professional standards. By making assessment metacognitive in this context, we can prepare students to maintain this awareness throughout their careers.

Building Communities of Learners

Reflecting on his invention of the virtual high school (VHS) concept, Tinker (2005, p. 413) concluded that "Without collaboration, the social value of networking is lost and online courses become simply extensions of existing course formats." Riel (2005, p. 315-316) identifies three overlapping ways in which online education should be community based: (1) collaborative learning in the context of a student cadre, (2) theoretical learning through community experiences, and (3) transformational learning in one's community of practice. In Serf, I have created a community building component called the affinity cluster. Instructors who own an affinity cluster have the power to create one or more affinity groups, each of which can consist of one or more threaded discussion forums, document sharing libraries, and electronic magazines (*a.k.a.* newsletters). A role-based permissions model enables the instructor to assign privileges to end users, who can be given read, write, moderator, or administrator access to one or more affinity groups.

Affinity groups can have different kinds of purposes and targeted audiences. Some groups may be intended for experienced users to participate in multithreaded discussions, for example, while other groups may be intended for novices who need a simple menu-driven discussion forum. To categorize affinity groups according to different purposes, the instructor creates an organizational entity called a Community and assigns to it affinity groups that share the community's goals and objectives.

I believe a logical next step in the development of the communities would be to create a wiki-style knowledge building environment (KBE). This would help answer Romiszowski's (2005, p. 337) criticism that in spite of what is known about creating KBEs, IMS vendors have done little to build these kinds of cooperative learning protocols into their products.

Conclusion

In the book *How People Learn*, the chapter on technology concludes by stating that "Much remains to be learned about using technology's potential: to make this happen, learning research will need to become the constant companion of software development" (National Research Council, 2000, p. 230). I personally believe that e-learning will evolve to the point at which the computer becomes transparent. When that happens, we should remove the hyphen from the term e-learning. As Chute (2003) reminds us, Webster's unabridged dictionary defines the prefix e as meaning thoroughly, as in the word evaporize, which means to vaporize thoroughly. Thus, we may define the term *elearning* as meaning to learn thoroughly, which we will achieve by applying design principles from the science of learning to create effective multimedia teaching and learning environments.

This is what I have been attempting since I began working with educational technology 35 years ago. It is hard to predict how many decades remain for me personally to work in this exciting field. In 2004, I was honored to receive a pioneering award for creating the first Web-based course at the University of Delaware back in 1997. In my acceptance speech, I recounted a scene from the movie *Monty Python and the Holy Grail* in which the Dead Collector carts off to burial bodies dead from the plague. One of the bodies objects that it is not dead yet. Neither am I done yet. God willing, I hope to spend a few more decades inventing, teaching, learning, mentoring, contributing, and sharing as we work to get to the point at which our field can remove the hyphen from e-learning.

References

Allen, M.W. (2003). *Michael Allen's Guide to e-Learning*. Hoboken, NJ: John Wiley & Sons.

Allen, M.W. (2006). *Creating Successful e-Learning: A Rapid System for Getting It Right First Time, Every Time.* San Francisco, CA: Pfeiffer.

Bloom, B.S. (1968, May). Mastery Learning. In *Evaluation Comment*, *1*(1). Los Angeles: University of California at Los Angeles, Center for the Study of Evaluation of Instructional Programs.

Brown, J.S., Collins, A., and Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher, 28*, 32-42.

Bruning, R.H., Schraw, G. J., and Ronning, R.R. (1995). *Cognitive Psychology and Instruction*. Englewood Cliffs, N.J.: Merrill/Prentice-Hall.

Chute, A.G. (2003). From Teletraining to e-Learning and Knowledge Management. In M.G. Moore and W.G. Anderson, (Eds.), *Handbook of Distance Education* (pp. 297-313). Mahwah, NJ: Lawrence Erlbaum.

Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki, Finland: Orienta-Konultit.

Fuller, R., Zollman, D., & Campbell, T. (1982). *The Puzzle of the Tacoma Narrows Bridge Collapse* (Videodisc). Hoboken, NJ: Wiley Educational Software.

Hill, J.R., Wiley, D., Miller-Nelson, L., & Han, S. (2004). Exploring research on Internet-based learning: From infrastructure to interactions. In D.H. Jonassen (Ed.), *Handbook of Research on Educational Communications and Technology* (2nd ed.) (pp. 433-460). Mahwah, NJ: Lawrence Erlbaum.

Hofstetter, F.T. (1975, May). GUIDO: An Interactive Computer-based System for Improvement of Instruction and Research in Ear-Training. *Journal of Computer-Based Instruction*, *III*, 100-106.

Hofstetter, F.T. (1976). Foundation, Organization, and Purpose of the National Consortium for Computer-based Musical Instruction. *Journal of Computer-Based Instruction*, *3*, 21-33.

Hofstetter, F.T. (1978). Computer-based Recognition of Perceptual Patterns in Harmonic Dictation Operations. *Journal of Research in Music Education, 26,* 111-119.

Hofstetter, F.T. (1979). Controlled Evaluation of a Competency-based Approach to Teaching Aural Interval Identification. *Journal of Research in Music Education, 27*, 201-213.

Hofstetter, F.T. (1980). Computer-based Recognition of Perceptual Patterns in Chord Quality Dictation Operations. *Journal of Research in Music Education*, *28*(2), 83-91.

Hofstetter, F.T. (1981). A Model for Administering Computer-Based Education. In B. Lewis and D. Tagg (Eds.), *Computers and Education*. Amsterdam: North-Holland Publishing Company.

Hofstetter, F.T. (1997). Serf's Up! Teaching and Learning with Serf: Your Servant on the Internet. In *Virtual Learning Environments: AACRAO Policy Summit* (pp. 123-135). Washington, DC: American Association of Collegiate Registrars and Admissions Officers.

Hofstetter, F.T. (1999, Fall). Three waves of Serf, a Web-based Teaching and Learning Environment. *College & University Media Review*, pp. 99-123. Available: http://www.udel.edu/fth/serf/serf1-3.html. [author: I didn't see this ref in text. If it should be there, please insert as appropriate. Otherwise, delete here]

Hofstetter, F.T. (2006). Serf 4.0. Newark, DE: Serfsoft Corporation. Available: http://serfsoft.com.

Homberg, B. (2003). A Theory of Distance Education Based on Empathy. In M.G. Moore and W.G. Anderson (Eds.), *Handbook of Distance Education* (pp. 79-86). Mahwah, NJ: Lawrence Erlbaum.

Kulik, C.C., Kulik, J.A., & Bangert-Downs, R.L. (1990, Summer). Effectiveness of Mastery Learning Programs: A Meta-analysis. *Review of Educational Research*, *60*(2), 265–299.

Lockee, B., Moore, D., & Burton, J. (2004). Foundations of Programmed Instruction. In D.H. Jonassen (Ed.), *Handbook of Research on Educational Communications and Technology* (2nd ed.) (pp. 545-569). Mahwah, NJ: Lawrence Erlbaum.

Moore, M.G. (1993). Theory of Transactional Distance. In D. Keegan (Ed.), *Theoretical Principles of Distance Education* (pp. 22-38). London: Routledge.

National Research Council. (2000). *How People Learn* (expanded edition edited by J.D. Bransford, A.L. Brown, and R.R. Cocking). Washington, DC: National Academy Press.

Nievergelt, J. (1980, September). A pragmatic introduction to courseware design. *Computer*, pp. 7-21.

Riel, M. (2005). Building Communities of Learners Online. In G. Kearsley (Ed.), *Online Learning: Personal Reflections on the Transformation of Education* (pp. 309-320). Englewood Cliffs, NJ: Educational Technology Publications.

Romiszowski, A.J. (2005). Online Learning: Are We on the Right Track? In G. Kearsley (Ed.), *Online Learning: Personal Reflections on the Transformation of Education* (pp. 321-349). Englewood Cliffs, NJ: Educational Technology Publications.

Rumelhart, D.E. (1981). Schemata: The Building Blocks of Cognition. In J.T. Guthrie (Ed.), *Comprehension and Teaching: Research Reviews* (pp. 3-26). Newark, DE: International Reading Association.

Saettler, P. (2004). *The Evolution of American Educational Technology*. Greenwich, CT: Information Age Publishing.

Skinner, B.F. (1938). *The Behavior of Organisms*. New York: Appleton-Century-Crofts.

Skinner, B.F. (1953). *Science and Human Behavior*. New York: Macmillan.

Skinner, B.F (1986, October). Programmed Instruction Revisited. *Phi Delta Kappan, 68*(2), 103-110.

Tinker, R. (2005). Learning Through Online Collaboration. In G. Kearsley, (Ed.), *Online Learning: Personal Reflections on the Transformation of Education* (pp. 402-414). Englewood Cliffs, NJ: Educational Technology Publications.

Vygotsky, L.S. (1978). *Mind in Society: The Development of Higher Psychological Processes.* Cambridge, MA: Harvard University Press.

Wenglinsky, H. (1998, September). *Does It Compute? The Relationship Between Educational Technology and Student Achievement in Mathematics*. Princeton, NJ: Educational Testing Service (ETS) Policy Information Center. Retrieved 22 December 2006 from http://www.ets.org/Media/Research/pdf/PICTECHNOLOG.pdf.