

Evaluating Technology and Instruction: Literature Review and Recommendations

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Executive Summary

The Division of Instructional Innovation and Assessment (DIIA) received funds in 2002-2003 from the Information Technology Advisory Committee (ITAC) to study UT Austin's use of technology in teaching and learning, which is described in the report "Assessment and Evaluation of the Use of Technology in Teaching and Learning at the University of Texas at Austin: Final Report for 2002-2003" (Gaede, Svinicki, Herndon, Decker, & Evans, 2003). One recommendation from the study was to conduct a literature review to answer three questions:

1. What theories have guided assessment and evaluation efforts?
2. What assessment and evaluation models have been used?
3. What results have been reported?

With these questions as a guide, the literature review revealed eight key trends in evaluating technology and instruction:

1. No one accepted definition of technology exists among educators, researchers, and evaluators. Most often, they use the term as an inclusive phrase to mean any type of equipment or application, inside or outside of the classroom, both computer-based and not, that is used to aid the learning process.
2. There is debate within the literature on the effectiveness of using technology to help students learn. Critics of technology-use in the classroom claim that the method of instruction, not the medium, causes learning to take place. Proponents of technology-use contend that researchers and evaluators should consider what teaching and learning strategies facilitate the learning process and then study which technologies best support those practices.

3. The primary benefits of technology include improvements in efficiency and access to information, the capability to tap into cognitive processes that facilitate learning, the integration of technology into the world of today's students, the flexibility in adapting to individual differences in learning, and the demand by businesses for skills developed by using the Internet.
4. Three questions should guide the adoption and evaluation of technology in the learning process: Does the technology increase access to learning? Does it promote improved learning? Can both be attained without increasing the cost of education?
5. The models most frequently used by researchers and evaluators to understand the impact of technology on learning are: 1) describing the universe—describe certain characteristics of interest to stakeholders; 2) applying criteria—compare current conditions with pre-technology conditions; 3) comparing institutions—compare how technology is used on various campuses; 4) improving programs—gather information during program implementation to improve the program; 5) identifying outcomes—identify important outcomes either intended or unintended; and 6) justifying programs—determine whether a program has met its goals to justify decisions previously made.
6. Commonly collected data from evaluations of technology consist of exam scores, standardized test scores (specific content areas, critical thinking ability, reading comprehension), course grades, course assignments, student behaviors, student attitudes, student retention, instructor ratings, and costs.
7. Common data collection tools include tests, journals, surveys, interviews, observations, and activity measures (audit trials, tracking tools).

8. Gaps in previous research show that little is known about how technology changes teaching and learning practices, that there is a mismatch between the skills used with learning technologies and outcome measures, and that methodology should incorporate observational validation of self-reports and longitudinal analyses.

Based on this review, seven recommendations were made for conducting future evaluations:

1. Develop a means of accounting for the per-credit-hour technology fee UT Austin students are charged to determine how the fund is being allocated.
2. Establish goals for technology use on campus. What are the short-term and long-term plans for technology use at UT Austin? Evaluation must be linked to these goals.
3. Establish goals and outcomes for technology and evaluation for DIIA. What are the desired outcomes for DIIA's various programs? What questions will DIIA be asked to respond to by various stakeholders? How can DIIA design an evaluation that tells if stakeholder needs are being met?
4. Connect the use and study of learning technologies to good, sound pedagogical and cognitive principles.
 - Link technological features to instructional variables. DIIA should begin to explore how various features of the technologies available in our classrooms can be linked to how an instructor teaches material.
 - Examine how/which technologies can be used to influence the learning process, especially in terms of cognitive processes. There is very little research on this issue.
 - Examine motivation and other psychological variables.

- In view of the absence of research on these points, DIIA will be on the cutting edge of research and program evaluation if the unit begins to make these connections and include these variables in research and evaluation designs.
5. Choose methodology appropriately.
 - Use mixed methodologies. Quantitative and qualitative data will help to give a richer and clearer picture of what is going on for various stakeholders.
 - Incorporate a longitudinal perspective into analyses.
 - Combine the collection of self-report data with observational data collection.
 - Refine outcome measures and match them to program objectives.
 6. Continue to conduct implementation evaluations.
 7. Use formative evaluations, during program implementation, because of their importance in the face of rapid technology changes.

Introduction

All of us wish we had good data about teaching, learning, and technology, but few institutions are doing the work to get it. That's dangerous. Technology changes quickly and unpredictably, IT budgets are large and getting larger, and money remains tight. Lacking data, faculty and administrators make big investments of time and money with their eyes closed. In today's world, it is important to get information that helps us see what we are doing, fix problems, and document achievements. (Ehrmann, 1999, p. 31)

Stephen Ehrmann's fear that the payoff of spending for technology is not being empirically evaluated is echoed in some form or fashion by many administrators, staff, and faculty across the nation. In the fall of 2003, The University of Texas at Austin began to explore this very issue. As a result, the Division of Instructional Innovation and Assessment was charged with assessing whether the \$13 million in student fees for technology enhancement in the classroom was being spent appropriately. To help answer this question, it is important to understand how researchers and evaluators have examined the use of technology in education in the past. To this end, this review of literature concerning evaluating technology and instruction covers five areas: definitions of technology, the role of technology in the learning process, the benefits of using technology in the learning process, methodological aspects of conducting evaluation of technology and instruction, and gaps in previous research. Following the review are recommendations for the Division of Instructional Innovation and Assessment as well as for The University of Texas at Austin.

Defining Technology

In order to set the context for the evaluation of technology in education, it is important to note that, generally speaking, there is no one accepted definition of what constitutes technology. The term is used very loosely to describe a variety of ways computers are integrated into the learning process. Descriptors for technology used in the classroom include, but are not limited to, the following: technology-mediated learning, computer-aided instruction, distance education, distance learning, educational technology, home learning technologies, computer-based education, instructional technology, multimedia, communications systems, Web-based learning, educational multimedia applications, and computer-mediated communication.

The variability in terminology appears not to be a matter of disagreement among researchers and evaluators. Simply put, technology is a word that is used to describe different things to different people. Technology is a term that is used by many to describe, study, and evaluate the various ways computers are integrated into education, both inside and outside of America's classrooms. Some authors are specific in describing specific technologies or applications; other authors simply use the term technology to describe everything electronic. Moreover, there is no consensus about what constitutes technology in learning or teaching. However, the common link tends to be some use of the personal computer to aid teaching or learning in some form or fashion. These technologies run the continuum of integration in education from entire courses put on the Web to technology integrated into a specific lesson.

Though most research studies focus on computer-based technology, there are other teaching and learning technologies that are not computer-based. These can include overhead projectors, document cameras, laser pointers, robotics, television, VCR, DVD, demonstration

equipment, sound systems, CDs, tape recordings, simulation machines, and models. Some evaluators even consider the traditional piece of chalk and chalkboard a type of technology.

In this paper, technology will be used as a term that could include any type of equipment, inside or outside the classroom, that is used to aid the learning process. This can include any of the technologies mentioned above as well as computer-based technologies, hardware, software, or Web-based learning. Specific technologies may be mentioned in reference to specific studies, but technology will be used as a catch-all term.

Technology and Learning

Within the literature on technology and learning, there is a debate raging among researchers and theorists concerning the effectiveness of using technology to help students learn. Generally speaking, there is an assumption that technology fosters learning merely by its use in the educational process. Ehrmann (1999) sums up this assumption very nicely:

Technologies such as computers (or pencils) don't have predetermined impacts; it's their *uses* that influence outcomes. This statement seems obvious, but many institutions act as though the mere presence of technology will improve learning. They use computers to teach the same things in the same ways as before, yet they expect learning outcomes to be better. (p. 32)

However, not all researchers, evaluators, or theorists agree that simply the presence of technology helps the learning process. As such, two camps have formed in regard to this issue.

Richard Clark is probably the most outspoken researcher who argues against the view that media by themselves influence the learning process. In his groundbreaking essay, Clark (1983) said succinctly: "...media are mere vehicles that deliver instruction but do not influence

student achievement any more than the truck that delivers our groceries causes changes in our nutrition” (p. 445). When this article was published, media was the term used for various technology applications; however, the term technology could easily be substituted in place of media (Clark, 1994). In essence, Clark believed that media do not help students to learn in any circumstance and that the instructional method is the source of the learning:

I accept the point that whenever learning occurs, some medium or mix of media must be present to deliver instruction. However, if learning occurs as a result of exposure to any media, the learning is caused by the instructional method embedded in the media presentation. (p. 26)

Further, he posited that different types of media could be substituted for each other, because media are not responsible for any learning that might take place. Media are not the causal agents in the learning process; rather, instructional method is the active ingredient or catalyst that causes learning to take place.

Clark is not alone in his stance that media (technology) do not influence learning. Thomas Russell’s (2001) comparative annotated bibliography, *The No Significant Difference Phenomenon*, catalogs 355 distance education studies in which researchers found that learning outcomes from distance education did not differ significantly from traditionally-taught courses. Based on these results, the author made the case that both methods are equally effective and one could be substituted for the other depending upon the situation. Russell (2001) did not conclude that distance education should be eliminated. However, he did make the point that having students learn solely by using distance courses is a very costly alternative to traditional courses.

In contrast to Clark’s argument, Kozma (1994) believed that the more appropriate question was not whether media **do** influence learning, but **will** they influence learning. He also

contended that simply because we have not established a relationship between media and learning does not mean that one does not exist. He believed that, since we do not fully understand the relationship between media and learning, we have yet to measure it, and the failure to establish this relationship is caused in part by our theories of learning, or more specifically, behaviorism, with its basic assumption that a stimulus causes a response. Therefore, if the stimulus is not present, there is no possibility for response. Kozma (1994) explained that in Clark's view media are simply "mere vehicles" or conduits for an instructional method (stimulus) that elicit a response (learning). Kozma argues that learning is a much more complex process than just a series of stimulus-response connections. Learning, in his view, is defined as "an active, constructive, cognitive and social process by which the learner strategically manages available cognitive, physical and social resources to create new knowledge by interacting with information in the environment and integrating it with information already stored in memory" (p. 8). Thus, in Kozma's view, since the definition learning has evolved to embody more of a constructive process, our measurement of this process must evolve as well.

Still others have argued for a complete reframing of the debate over technology and its effect on learning. Jonassen, Campbell, and Davidson (1994) believed that the Clark/Kozma debates focused too much on instruction and media and not enough on the attributes of the learner who ultimately constructs the knowledge. They proposed that researchers examine how media can support the learning process. To accomplish this goal they suggested that learning be treated as situationally dependent by taking into account the context in which knowledge is constructed. For example, we know from learning theory that learning is most effective when it is situated within the context of a meaningful, real-world activity or task (Jonassen et al., 1994). Moreover, the authors also suggested that we study how to support maximizing the human

information processing system. One example of this maximization is capitalizing on the limited capacity to process information (attention). Technology can be used to design a specific lesson that reduces the cognitive load on a student while freeing up resources for higher-level thinking (Jonnasen et al., 1994). In sum, Jonnasen et al. (1994) argued that the focus of the debate should be returned to the learner rather than remain on methods or attributes of media.

With all the various opinions on the relationship between technology and learning, it begs the question: who is right? It appears that each theorist brings an important perspective to the table. Clark is correct that technology has not necessarily revolutionized the process of learning. Technology has not helped humans develop a new way to learn. Learning is still something that is performed by the individual. However, in Clark's view, all an instructor would need to do is embed the appropriate instructional method into his/her lesson and learning should take place. We know, however, despite many instructors' best efforts and superior teaching abilities, learning does not always take place. Kozma is also correct that we must examine technology and learning beyond a behaviorist context. Learning is an intentional act (Jonnasen et al., 1994) and the human being doing the learning should not be discounted. Researchers have established that there is no significant difference between learning with technology in distance education courses and learning in a traditional classroom, but they do not discuss how human motivation is influenced by technology. This could be a very important missing element in the debate.

Which side you take in this debate depends largely upon how you define learning. If you subscribe to more behaviorist views of learning, Clark will make more sense to you. If you conceive of learning as a more cognitive or constructivist process, you would be more likely to agree with Kozma or Jonnasen et al.

Benefits of Technology

The question asked by researchers is whether technology improves learning. As we have seen in the literature so far, technology does not increase learning over and above traditional methods (Ehrmann, 1999). Many take this as bad news, but the reality is that learning is still taking place. This is good news. The more appropriate question should be, how can technology be used to help the learning process? From the literature that follows, it is possible to detail the various benefits to incorporating technology into the learning process.

Technology in the classroom can definitely help improve access to information or types of information. Moreover, we can access the information in an efficient manner. Using Clark's metaphor, the truck that delivers the groceries might not cause any kind of change in a person's nutrition, but a truck delivering groceries is more efficient than a horse and buggy. People have made wise as well as unwise decisions throughout history. Technology simply helps us to make these decisions, be they good or bad, more quickly.

There are appropriate and inappropriate uses for technology in the classroom. Appropriate uses can help facilitate the learning process while inappropriate uses can hinder it. For example, the document camera can be used to show many types of visual aids, well above and beyond the old-fashioned stand-by, the overhead projector. However, learning depends upon how it is used.

Technology needs to tap the cognitive processes we know actually work. For example, encoding through visualization can be accomplished through the use of technology. Because part of a learner's job is to put information into memory using some type of visual cue, a chemistry instructor can use a computer to display three-dimensional images of molecules while explaining a chemical reaction. This type of visualization is much more rich and detailed than

simply trying to draw a two-dimensional image on the chalkboard, and so this use of technology makes the reaction easier for the learner to remember.

However, technology can be a double-edged sword if the instructor is not properly trained in pedagogy and the technical aspects of using technology. For example, simply slapping up the textbook on the document camera might not accomplish the goal of learning, especially if the instructor fails to zoom and focus on the desired image. Knowing how and when to use various technologies in the classroom will greatly help the students grasp the material during class time.

Other technological advances, such as simulations and/or expert systems, can provide safe experiential learning not possible in the real world and not available from simply reading a two-dimensional textbook. For example, one skill that medical students must learn is how to diagnose diseases. Expert systems have been developed through which students are presented with a whole host of symptoms, and they must order the appropriate tests to allow them to come up with a diagnosis and treatment plan for their patients. The expert system evaluates the students' diagnoses and lets them know if their patients live. This all takes place in a virtual environment where real lives do not hang in the balance. Moreover, this type of problem-based learning cannot be gained from just reading a textbook.

Learning processes do not change just because technology is integrated into the classroom. Technology allows us to access more information faster and in an efficient manner. We spend less time searching and more time on decisions. We can create real-world simulations, and three-dimensional models that can help us remember information. Instructors can grasp the attention of their students more easily and teach in multiple modes that affect more than one sense (seeing and hearing, for example). Moreover, we know that certain instructional methods

influence certain cognitive processes, and for learning to occur, these cognitive processes must happen. To the extent that instruction does not support essential cognitive process, learning will be impeded, unless the student is an expert in learning information on his or her own. Thus it is incumbent on the instructor to take the time to learn how to incorporate technology into his or her teaching, based on sound pedagogical principles.

So why use technology at all in light of this debate about its usefulness and especially when there are other competing factors for an instructor's time? Competition is fierce for keeping teaching positions, and technological failure in the classroom could decrease evaluation ratings (Cardenas, 1998). Yet, it takes a lot of time to develop and integrate technology in the classroom (Cardenas, 1998), not to mention the expense for hardware, software, and ongoing support.

Owston (1997) suggested three advantages of integrating the World Wide Web—and by extension, other forms of technology—into teaching and learning. First, the Web appeals to students' mode of learning. He describes internet use as being “integral to their world” and thus it is a preferred tool for learning. Students start very young using computers and the Web in school. By using the Web, an instructor is tapping into a student's current context for exploring the world. Second, the Web provides for flexible learning. Students have access at their convenience. The lack of face-to-face contact can help shy students participate in the learning process. Moreover, asynchronous and synchronous communication are possible. Third, there is renewed demand for skills that can be acquired by using the Web in the learning process. In today's global economy, skills such as critical thinking, problem solving, writing, and working collaboratively are required of everyone. While these technically are not new skills, there is renewed demand for their development. Owston argues that the Web is a natural tool for the

development of these skills, because students have to surf sites and judge their content and authenticity, compare differing viewpoints, analyze and synthesize vast amounts of information, and construct their own understanding of a topic. Students can also gain practice at writing to a key audience using the Web. Moreover, group projects can be designed for publishing on the Web, encouraging collaboration among students.

With an understanding of the context in which technology and education have been examined over the years, the following sections detail the methodological aspects of evaluating the use of technology in the classroom.

Evaluating the Impact of Technology

As technological advances continue to evolve and proliferate, educators and administrators have sought to integrate technological innovation into the classroom. With this rise in implementation and demand comes an increased need to evaluate the effectiveness of technology in education (Owston, 1999, 2000; Windschitl, 1998). Indeed, technology evolves at such a fast pace that oftentimes conclusions from summative studies are dated by the time they are completed (Heincke et al., 1999). Fast-paced technological development also makes it difficult for researchers to do theoretically grounded and rigorous research that should guide the development and adoption of technology in learning environments (Alavi & Leidner, 2001). As such, calls for greater depth and breadth in research abound.

Theorists also caution researchers to remain leaders in integrating technology into the classroom while not losing sight of the pedagogical dimension of technology. Due to the widespread interest in technology and the possibility of economic gain, Alav et al. (2001) warn that “profit motives may start to drive the field. As researchers and educators, we may find

ourselves on the sidelines of our own game” (Alavi et al., 2001; Reigeluth, 1989). As in other sectors, there is pressure to be the first to integrate the newest technology into educational practices, pressure that causes educators to be the first to jump on the technology bandwagon. However, researchers in higher education (Owston 1997, 1999, 2000) do caution against knee-jerk reactions to this pressure by proposing to establish broad-based questions to guide the adoption of technology in the educational process:

- 1) Does the Web increase access to learning?
- 2) Can the Web promote improved learning?
- 3) Can increased access and improved learning be attained without increasing the unit cost of education?

In essence, questions such as these help those in the education field avoid adopting new technologies simply because they are new, fast, or engaging for the user. There should be a pedagogically-grounded reason for adopting a new technology for educational purposes.

Ehrmann (1995) believes that we would be better served by seeking educational change first by beginning with educational objectives and then using the proper tool to fit the objective. He is arguing that we discover the appropriate technology for a given teaching task. “There are several tools that can be used to turn a screw, but most tools can’t do it, and some are better for the job than others” (Clark, 1983). Ehrmann (1999) suggests that we study which teaching and learning strategies facilitate the learning process (especially those only possible by using new technology) and then study which technologies best support those teaching and learning strategies.

Additionally, questions such as these are meant to help educators and administrators plan an evaluation component into the theoretically-grounded adoption of new technologies in the classroom. While most researchers in the field would agree with this stance, Ehrmann (1995)

cautions evaluators about making decisions solely based on the unit cost of a program, because this can be difficult to estimate. Evaluations of technology based on principles of teaching and learning will surely bring us a step forward in understanding not only which technologies work best, but why.

In the following sections I consider how evaluators have attempted to assess and evaluate the impact of technology in higher education, with three perspectives: approaches to evaluation, data sources, and data collection techniques. A discussion of gaps within the current research will follow.

Evaluation Approaches

It is important to use a variety of models and methods when evaluating technology and learning, because learning environments and stakeholder needs are multifaceted (Owston, 2000). One model or framework is unlikely to capture the complexity of the relationship between technology and learning, especially in view of pedagogical, organizational, institutional, and technical issues (Owston, 2000). Evaluators have developed numerous methods to account for this complexity. Of the many approaches to the evaluation of technology and instruction in the literature, theorists (Jackson, 1990; Young, 2002) note six major ones, to be discussed below. They are: describing the universe, applying criteria, comparing institutions, improving programs, identifying outcomes, and justifying programs

Describing the universe This type of evaluation is conducted to simply describe certain characteristics of interest to a stakeholder. In higher education, a descriptive evaluation could include describing features such as hardware, software, typical student access to

computing, or faculty involvement with learning technology on a particular campus. The main objective is to understand broad patterns with little attempt to generate anything more than an accounting of resources (Jackson, 1990; Young, 2002). Examples of such evaluations include determining the number of computers on campus, the number of classrooms with technology enhancements, peak usage hours, and software most frequently used by students and faculty.

Applying criteria This type of evaluation is used to compare current conditions with pre-technology conditions. Institutions oftentimes require the use of technology based on an assumption that the technology will improve some aspect of learning. Evaluation is conducted to see if criteria for improvement have been met. Historical data, experimental data, and quasi-experimental data are all important sources for this type of evaluation (Bullock and Ory, 2000; Jackson, 1990; Young, 2002). The most common type of evaluation is a pre/post measure of student achievement or student attitudes in relationship to the use of technology (Bullock and Ory, 2001). Other names for this type of evaluation include objectives-based evaluation (Popham, 1972) and standards-based evaluation (Young, 2002). An example of a question appropriate for this kind of evaluation is: Did students' use of technology help them write better papers or use resources more efficiently?

Comparing institutions Administrators at one institution may want to know how learning technology is used at another institution, in possibly quantitative or qualitative terms (Young, 2002). This type of evaluation is concerned with how technology use on one

campus stacks up to experience with learning technology at other universities (Jackson, 1990). These types of studies can produce benchmarks for institutions to help motivate various stakeholders to improve existing technology (Young, 2002). Appropriate questions for this type of evaluation include: Are students more computer savvy at another university compared to this institution? Does this institution have better equipment than another university?

Improving programs This type of evaluation is formative, because the focus for an evaluator is to gather information to improve an existing program (Jackson, 1990; Young, 2002). This type of evaluation can inform an evaluator of intentional or unintentional potential outcomes, so that changes can be made before the completion of a program. For example, students might be given laptop computers to improve learning and efficiency, but evaluators may find that students use the computers for e-mail or games. A formative evaluation would cue evaluators to this trend (Jackson, 1990).

Identifying outcomes This type of evaluation is concerned with ascertaining the important outcomes, intended or otherwise, of the use of technology in the classroom (Jackson, 1990; Young, 2002). This concern implies that the original objectives of the program are initially identified. It is critical to examine the original objectives of a program so that the evaluator can develop an understanding of the domains in which changes are supposed to take place, in order to discover which mechanisms are responsible for the change (Young, 2002). Examples of appropriate questions for this kind of evaluation are: Did test scores change as a result of using this technology? Did

students' attitudes change as a result of this program (Young, 2002)?

Justifying programs This type of evaluation is concerned with assessing whether a program met its goals as a means of justifying decisions that have been previously made (Jackson, 1990; Young, 2002). With this type of evaluation, administrators try to assess if the results of the program justify the expenditures. This can be more of a political decision than a scientific decision (Young, 2002).

Bullock and Ory (2001) also mention three other types of evaluations that appear less often in the literature: illuminative (Stake, 1978), participatory (Cousins & Earl, 1992), and integrative (Draper, Brown, Henderson, & McAteer, 1996). Illuminative evaluations use qualitative techniques to describe the impact of technology. Measuring the impact of technology is not the main focus. Rather, the goal of this type of evaluation is to uncover problems, issues, or concerns. Participatory evaluations “involve a partnership between evaluation personnel and different evaluation audiences” (Bullock & Ory, 2000, p. 318). The important thing to note about participatory evaluations is that evaluation is integrated into each phase of a program, so that evaluators work with all stakeholders involved. Integrative evaluations are concerned with the goal of effectively integrating technology into a teaching and learning situation (Bullock & Ory, 2000).

In addition to six primary approaches to evaluating technology, there are three main focuses involved in evaluation studies as described by Young (2002). First there is the focus on the technology itself—the availability and use of different types of software. The second focus is on the technology and user interface. The third focus is the users' experiences with various types of technology. This discussion seems to focus only on the student as a user of technology and

the technology itself (hardware/software). However, it would seem appropriate that other focuses be included, especially in relationship to other stakeholders such as administrators and faculty.

Sources of Data

The types of data collected for evaluations of learning and technology include but are not limited to the following: exam scores, standardized tests scores (specific content areas, critical thinking ability, reading comprehension, spatial relations), course grades, course assignments, student behaviors, student attitudes, student retention, instructor ratings, and costs (Bullock and Ory, 2000).

These types of data are generally used as outcome measures in evaluations and appear to be very typical. It is also important to note that researchers on technology and learning recommend changes in practices within this field with regard to the type of data collected. There is a call to refine and expand definitions of student learning outcomes (Heinecke et al., 1999; Shakeshaft, 1999). There is a tendency on the part of administrators to falsely assume that, when technology is integrated into the classroom, achievement scores will increase (Shakeshaft, 1999). Typical standardized achievement tests might be the only measures currently at our disposal, but they do not give us a complete picture of what a student learns. Thus, there is a push to move away from gain scores as an outcome variable in program evaluation studies (Heinecke et al., 1999).

Within the literature, researchers do make recommendations about different traits or variables to be measured in order to create a bigger picture of technology and learning. For example, Young (2002) suggests that dependent variables be linked to current developments in

cognitive psychology. One of these tenants of cognitive psychology is that learning is an active process and is facilitated when a learner becomes active with the material as opposed to listening to a lecture on autopilot. So, one important variable to measure would be: To what extent does technology facilitate active learning? Performance scores on achievement tests do not tap into this important domain.

Researchers also suggest measuring other outcome variables when evaluating technology and learning. Young (2002) suggests that evaluation should also consider if students' affect and behaviors regarding learning are changed. Moreover, he poignantly suggests that evaluators check to see if the technology is applied haphazardly or if it is central to the context of the learning. Other researchers call for greater research into underlying psychological processes (Alavi & Leidner, 2001) such as positive perception of the situation, challenge, fear of mistakes, and performance in virtual classroom situations (Papa, Perugini, & Spedaletti, 1998). In addition, missing from current analyses are consideration of internal processes such as information processing, motivation, interest, or memory. Learning takes place through all of these mechanisms (Papa et al., 1998). Moreover, the link between technological features and instructional variables that might influence learning outcomes has not been explored. Shavinina and Loarer (1999) suggest that developers of educational technology and evaluators should consider exploring five relatively independent yet interrelated dimensions: 1) the individual (such as basic cognitive processes, intellectual functioning and creativity, developmental specificity, motivation/emotional characteristics, knowledge acquisition skills, metacognitive processes, and knowledge transfer), 2) the learning approach or model (learning style), 3) the specific characteristics of the technology, 4) the environment (context), and 5) the relationship among these dimensions. Shavinina and Loarer (1999) believe there is a complex interaction

between the student's psychological make-up, cognitive psychology, technology, and the larger context. When making evaluations about technology in education, future research should begin to incorporate some of these factors.

Methods for Collecting Data

Numerous methods for collecting data are described within the literature, falling into six general categories: testing, journals, surveys, interviews, observations, and/or activity measures (Jackson, 1990; McKenna, 1995; Bullock & Ory, 2000).

Testing Testing can include in-class exams or quizzes as well as standardized testing. The advantage of this method of data collection is that exams are a routine part of our educational system and scores are readily available. The drawback of testing is that, in and of themselves, test scores do not give us a detailed picture of learning with technology.

Journals Teacher or student journals can help to give us a very detailed picture of the learning process. However, as with all self-report instruments, there is the possibility of teachers or students reporting what the researcher wants to hear (the Hawthorne effect). Plus, analyzing and summarizing such qualitative data can be difficult and time consuming, often requiring a high-level of expertise and considerable cost.

Surveys Self-report surveys can be open-ended or multiple-choice. They can provide a great deal of information in a short time. However, there are problems associated with

surveys. First, survey development requires time and expertise. Second, while surveys are generally designed to document activity, they can only do so indirectly. Third, if students misunderstand questions, the results may be difficult, at best, to interpret (Jackson, 1990).

Interviews Interview formats can include face-to-face, written question and answer, or focus groups. Interviews can follow formal protocols or informal question and answer format. Interviews have the benefit of allowing the researcher to follow up on interesting responses that were not expected. The principal drawback is that a good interview requires much skill and experience, so they are expensive and time-consuming (Jackson, 1990).

Observations Observations can be a rich source of data and can be conducted live or videotaped. They allow the evaluator to gather a wealth of information and describe themes running through the observed events. Observations also allow the evaluator to check if information obtained through self-report techniques is accurate in reality. However, conducting observations requires skill, training, and expertise, and so they can be expensive and time-consuming (Jackson, 1990).

Activity measures Activity measures can include audit trails obtained using some type of tracking device. They are used to help the evaluator to assess context, patterns of use, and types of learning technology. While they can provide a basic understanding of the

context, they are also limited because they describe only behavior, not the reasons for the behavior (Jackson, 1990).

Combinations A combination of these methods for data collection can provide greater depth of information, because behavior can be linked to explanation (Jackson, 1990).

There is also a push to combine qualitative and quantitative methodologies. Two major reasons are found in the literature. First, Bullock and Ory (2000) note that quantitative studies have a tendency to fail to explain why something happened while qualitative studies have difficulty establishing general results. They suggest using a hybrid approach to help draw a more complete picture of what happens when technology is used in helping students to learn. Second, Owston (1999) and Heincke et al. (1998) suggest that there is value in mixing quantitative and qualitative methodologies when evaluating Web-based learning. (This could also be extended to other forms of technology.) Owston (1999) believes that this flexibility of mixing methodologies allows the researcher to focus on the predominance of the research question rather than the paradigm. Thus, the evaluator is free to choose whatever method helps answer a specific research question.

Windschitl (1998) proposed that other methodologies, such as qualitative analysis (grounded theory), case studies, or ethnographies, be used to examine this issue. He suggests that there is an overemphasis on confirmation or disconfirmation of hypotheses, which may distract researchers from discovering “subtle but powerful patterns of behavior that characterize social environments (virtual or real)” (p. 31).

Which methodology is chosen depends entirely on the research question. Young (2002) argues that the use of multiple methods will lead to more sound and reliable results than the use

of one single method. However, this will entail greater cost to obtain the expertise and management skills necessary for data collection. The strategy that a researcher would use in evaluating technology for instruction depends largely on how the following questions are answered: 1) What is the focus of the evaluation? 2) Who are the sources of data? 3) Will data be collected from individuals or groups? 4) Which domains of users' experiences are to be measured (affective, behavioral, cognitive, or a combination)? 5) Which methods will be used to collect the data? 6) Will the results be used to improve future uses of technology or will the results describe and summarize the outcomes? For example, if an evaluator is interested in users' experiences with a specific technology in learning context, he or she might choose to use activity reports, interviews, observations, and surveys.

Gaps in Previous Research

In the literature, researchers have noted very important gaps in their examination of technology and learning, centered around three broad categories: pedagogy, measurement, and methodology.

Concerning pedagogy, we know very little about how the introduction of technology into the classroom changes learning and teaching practices (Mergendoller, 1996; Windschitl, 1998; Ehrmann, 1999). More specifically, researchers are calling for the examination of the effects of incorporating the World Wide Web as a learning tool in large lecture courses at the college level (Ehrmann, 1999). There definitely needs to be a stronger research focus on the interaction between technology, pedagogy, curriculum, and student learning as influenced by the WWW and other technologies, given that universities invest a great deal of time and money in these technologies (Mergendoller, 1999; Windschitl, 1998). Clear statements of program goals and

more rigorous research designs could help fill in this gap (Jackson, 1990).

Concerning how student learning is measured, in most evaluation studies there is a mismatch between the skills used with learning technology and outcome measures. For example, a specific technology might be used to improve analytic skills or problem solving skills in the classroom, yet researchers will use student achievement scores as a measure of success. This is problematic because traditional measures of student achievement, especially standardized tests, do not account for improvement in analytic or problem solving skills (Jackson, 1990; Means, Haertel, & Moses, 2003). Because of this mismatch between skill and measure, it is no surprise that researchers have yet to demonstrate many significant differences between students taught with technology integrated into the lesson and those taught with traditional methods. Evaluators in the future will need to refine their measures as well as match the outcome measure with the objectives of a program. Finally, there is a need for more multifaceted tools for evaluation as classrooms become more multifaceted because of the implementation of new technologies (Heincke et al., 1999).

Concerning methodology, researchers call for combining observational data with self-report data collected from students and professors to independently validate the self-report data (Jackson, 1990; Heincke, 1999). In addition, as instructors begin integrating more technology in their lessons, longitudinal analyses will become more necessary to examine changes over time (Heincke et al., 1999). Researchers also urge administrators to conduct more formative evaluations because changes in technology are so rapid that conclusions from summative studies are outmoded by the time they are published. Administrators should continue to do implementation evaluations to discover to what degree an innovation was adopted (Heincke et al., 1999).

Recommendations for DIIA

Based on this review of the literature on technology and learning, I recommend DIIA and The University of Texas at Austin take these steps in conducting future evaluations:

- Develop a means of accounting for the \$10.45 per credit hour technology fee students are charged. Conducting broad-based program evaluation does not make sense if we do not know how such a large \$13 million fund is being allocated.
- Establish goals for technology use on campus. What are the short-term and long-term plans for technology at UT Austin? Evaluation must be linked to these goals.
- Establish goals and outcomes for technology and evaluation for DIIA. What are the desired outcomes for our various programs? What questions will DIIA be asked to respond to by our various stakeholders? How can we design an evaluation that tells us if we are meeting their needs?
- Connect the use and study of learning technologies to good, sound pedagogical and cognitive principles.
 - Link technological features to instructional variables. We should begin to explore how various features of the technologies available in our classrooms can be linked to how an instructor teaches material.
 - Examine how/which technologies can be used to influence the learning process, especially in terms of cognitive processes. There is very little research on this issue.
 - Examine motivation and other psychological variables.

- In view of the absence of research on these points, DIIA will be on the cutting edge of research and program evaluation if we begin to make these connections and include these variables in our research and evaluation designs.
- Choose methodology appropriately.
 - Use mixed methodologies. Quantitative and qualitative data will help to give us a richer and clearer picture of what is going on for various stakeholders.
 - Incorporate a longitudinal perspective into our analyses.
 - Combine the collection of self-report data with observational data collection.
 - Refine our outcome measures and match them to program objectives.
- Continue to conduct implementation evaluations.
- Use formative evaluations because of their importance in the face of rapid technology changes.

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