

CHAPTER 12

Enhancing the Worth of Evaluation

Objectives

After reading Chapter Twelve, you should be able to:

- identify long-term benefits of evaluation to education and training;
- understand the complex relationship between research and evaluation in the field of educational technology; and
- conduct your evaluations within the context of “development research” so that you can use your evaluation results to improve your practice and contribute to the field of educational technology.

A line in the sand

Several years ago, Utah State University Professor M. David Merrill, one of the foremost experts in the field of educational technology, drew a metaphorical line in the sand that called for anyone committed to serious learning technology research to join him and his associates in pursuing an empirical research agenda based upon the fact that instruction is a science (Merrill, Drake, Lacey, & Pratt, 1996). Professor Merrill also contended that instructional design is a technology derived from the science of instruction based on principles that could be verified by empirical data.

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Not everyone shares Professor Merrill’s assessment of instructional design as a scientifically valid technology. Consider the following quote from Professor Lauren Resnick, a distinguished cognitive scientist from the University of Pittsburgh. These remarks were made at the 1999 Annual Meeting of the American Educational Research Association (AERA) in Montreal, Canada, when Dr. Resnick responded to a question from the audience about what kinds of people could do “design experiments” of the kind she was advocating to advance educational practice. Resnick said:

We don't have a well-developed design field in education, as a design field. So in our work, we do lots of design. Who's doing it? Well, there are some people who've traveled in from research that are doing it. There are some people who came from the world of schools, therefore practitioners, who turn out to have a tremendous flair for getting it shaped and codified so that others, besides themselves or a small in-group, can do it. I've looked around at the field called instructional design in which people can get degrees, and so far have not been interested in hiring any of the people with those degrees who have crossed my path. Just doesn't look like they were going to add much. In an hour or so and across this week, I will be interviewing students from some of the people here and some others of you who are out in the audience who I don't think have the word design on their curriculum vitae, but who look pretty promising to be the kinds of people we're talking about. So the real issue has to do with what would a design field in education that would be serious actually look like.

There is an enormous gap between Merrill's identification of instructional design as a robust technology derived from the science of instruction and Resnick's conclusion that instructional design is a field that does not seem to contribute to the solution of educational problems. This debate is not limited to the Ivory Tower. The cover story in the April 2000 issue of *Training* magazine (Gordon & Zemke, 2000) is titled "The Attack on ISD." According to the authors, "The 'systems approach' to instructional design is the training industry's guiding light. Some of the best minds in the business now say it's leading us astray" (p. 43).

Reflecting similar doubts, Dr. Robert B. Kozma, serving as a discussant for a session on applications of instructional theory and design at the AERA conference in Montreal in 1999, stated that instructional technology as a field is inward and backward focused, too disconnected from research and development in other fields, and insufficiently influenced by significant advances in technology (Ross, 1999). Of course, many, if not most, fields of inquiry are beset with similar controversies. For example, in biology, one camp of scientists is laboring mightily to explain the nature of human behavior on the basis of genetic mapping, whereas another camp argues that human behavior will ultimately be explained more completely by the effects of nurture and culture. If educational technology can be regarded as a field of inquiry, then it too must have its controversies. One of the most obvious disputes is between those who view educational technology as a branch of science or technology and those who regard it as more akin to a craft or even an art (Clark & Estes, 1998, 1999; Estes & Clark, 1999).

Another controversy concerns whether educational technologists should conduct basic research to build generalizable theories or pursue applied research to solve specific problems. We are much more convinced of the value of applied research than of basic research within the context of a design field such as educational technology.

So what does all this have to do with you as an instructional designer, project manager, or evaluator within the context of interactive learning systems? In this chapter, we argue that people like you can do more than simply conduct evaluations; they can extend the reach of their evaluations and contribute to design principles regarding interactive learning systems through a process called development research (van den Akker, 1999). But first, it is important to explain why we believe that the current dominant approaches to research in this field are inadequate.

Problems with research in interactive learning systems

Calling attention to problems with the research literature in educational technology has occupied scholars for decades (e.g., Clark, 1983; Hoban, 1958; Mielke, 1968), but many problems persist. Three significant problems with the research literature are highlighted in this chapter. First, major misunderstandings exist about the differences between basic and applied research. Second, the quality of published research in the field of educational technology is poor (although no poorer than educational research in general). Third, syntheses of the research focused on interactive learning systems, such as literature reviews and meta-analyses, provide practitioners with insufficient or confusing guidance.

Basic versus applied research

Most evaluators, not unlike educators in general, hold a traditional one-dimensional view of research as ranging from “basic” (research aimed at extending fundamental understanding within a scientific field) to “applied” (research aimed at solving problems that confront an individual, a group, or society at large). Among educational technologists, there have long been arguments about the relative value of basic versus applied research (Merrill *et al.*, 1996). Evidence of the schism is seen in the division of one of the leading journals in the field, *Educational Technology Research and Development*, into separate research and development sections (Higgz, Sullivan, Harper-Marinick, & López, 1989).

Some people have a preference for basic research, regardless of whether it has any practical value, perhaps because basic research seems more scientific or because they believe that basic research will ultimately lead to more advances in the field than will applied research. Other people

believe that the value of basic research to the field of educational technology, and more specifically, to the design of interactive learning systems, is very limited. These people argue that applied research, focused upon direct and clear implications for practice, will yield greater progress.

Other research scholars maintain that traditional notions of basic and applied research are too simplistic. In a book titled *Pasteur's Quadrant: Basic Science and Technological Innovation*, Stokes (1997) recommended a matrix view of research (see Figure 12.1). Where a research agenda is placed within this matrix depends upon whether or not researchers are seeking fundamental understanding *and* whether or not they are concerned about practical uses of research findings. To illustrate the placement, Stokes stated that the research conducted by Danish physicist Niels Bohr, who sought pure knowledge about the structure of the atom without concern for practical application, belongs in quadrant 1. The research conducted by American inventor Thomas Edison, who sought to solve practical problems through the development of innovative technologies while expressing no interest in publishing his research findings, belongs in quadrant 3. Stokes placed the research of French chemist Louis Pasteur, who sought fundamental knowledge within the context of solving practical problems, within quadrant 2.

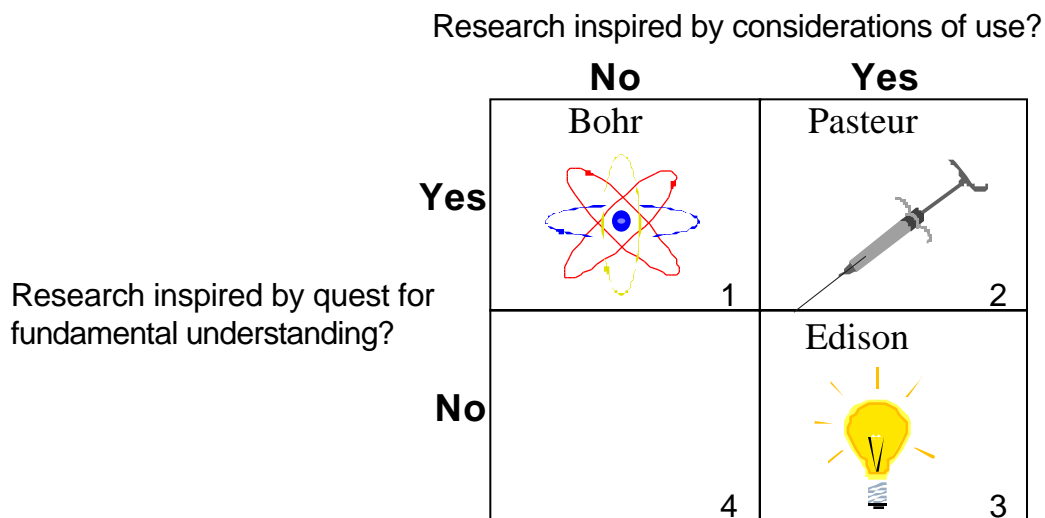


Figure 12.1. Pasteur's Quadrant View of Research (Stokes, 1997).

Although Stokes (1997) left blank quadrant 4, research that neither seeks fundamental understanding nor considers use, much of research conducted in the area of interactive learning systems (as well as educational research in general) belongs in this sterile quadrant. Such research is conducted and published solely to advance the careers of academics

confronted with the mandate to publish or perish. (When Tom Reeves first arrived at The University of Georgia in 1982, several College of Education professors advised him to get his hands on a large set of data so that it could be mined for multiple publications. Hardly anyone pointed him toward solving the problems confronting what was then and remains one of the most educationally under-achieving states in the USA. A new assistant professor at another university, after reading an earlier draft of this chapter, wrote to say that this situation has not changed much.)

Stokes (1997) called for increased “use-inspired basic research” of the kind conducted by Pasteur. Stokes also called into question the assumption that pure basic research leads to the development of new technologies. He pointed out that in contemporary science, new technological developments often permit the advancement of new types of research, thus reversing the direction of the basic to applied model. For example, the development of powerful computers and sophisticated data analysis software led to the growth of computational modeling as a viable approach to research in scientific fields from astronomy to zoology (Ilgen & Hulin, 2000).

Poor quality of educational technology research

Although more educational technologists appear to be adopting qualitative or mixed methodologies than was the case just a few years ago, when quantitative studies dominated the research literature (Reeves, 1995), there is little evidence that the quality of research has improved. The Panel on Educational Technology of the President’s Committee of Advisors on Science and Technology (PCAST) (1997) severely criticized educational technology research. The PCAST experts listed as one of its six major strategic recommendations that the government “initiate a major program of experimental research...to ensure both the efficacy and cost-effectiveness of technology use within our nation’s schools” (p. 5). Unfortunately, the PCAST panelists failed to explain how this additional experimental research would be better than the previous decades of experimental studies that have failed to establish the advantages of technology-enhanced education over more traditional approaches (Cuban, 1986). Nonetheless, support for traditional research approaches persists as evidenced by a November 2002 report titled *Bringing Evidence-Driven Progress to Education* from the Coalition for Evidence-Based Policy and The Council for Excellence in Government in Washington, DC. The authors of the report claim that there has been no improvement in education over the last 30 years, despite a 90 percent increase in real public spending per pupil. As a solution, they promote the use of randomized controlled trials as used in medical research to prove which interventions really work in education.

Regardless of methodological preferences, the bulk of the educational technology research literature is generated by isolated researchers, most often doctoral students and new faculty members, who conduct individual studies that are rarely linked to a robust research agenda. These studies do not constitute basic research in the classic scientific sense, nor are the studies focused on enhancing practice in an unambiguous manner. The main criterion for success of this research is that papers about it are accepted for presentation at conferences largely attended by other researchers or published in academic journals that few people read. A detailed analysis of such studies (Reeves, 1995) found that most are riddled with problems, such as specification error, lack of linkage to theoretical foundations, inadequate literature reviews, poor treatment implementation, major measurement flaws, inconsequential learning outcomes for research participants, inadequate sample sizes, inaccurate statistical analyses, and meaningless discussions of results.

Although some may interpret this as an overly harsh critique of educational technology research, we must point out that educational research in general has been subjected to similar criticism (Lagemann, 2000). In the first week of August 1999, the headline on the cover page of *The Chronicle of Higher Education* proclaimed “The Failure of Educational Research” (Miller, 1999). During the past 20 years, similar articles have occasionally appeared in *Educational Researcher* and other education publications (Kaestle, 1993), but this was the first time such an indictment appeared on the cover of the weekly newspaper of record for academics in the USA. For those engaged in educational research, it stings to see it condemned in such a public manner for its lack of substance and influence. But ignoring such critiques is irresponsible.

Disappointing research syntheses

Given the poor quality of the inputs to research syntheses in the field of educational technology, it is little wonder that the literature reviews and meta-analyses yield disappointing results that provide practitioners with confusing guidance. Reviewers usually must reject 75 percent or more of the published studies to find a handful that are worthy of further review or inclusion in a meta-analysis (Hunt, 1999; Kulik & Kulik, 1991).

The problems with instructional technology research were demonstrated in two literature reviews published in the *Review of Educational Research*, a highly-respected AERA publication. Dillon and Gabbard (1998) reviewed the literature concerning hypermedia in education, and Fabos and Young (1999) reviewed the literature examining telecommunications in the classroom. After reviewing nearly 500 papers related to hypermedia and learning, Dillon and Gabbard identified 118 studies that appeared to meet their criteria for quantitative studies examining the

effectiveness of hypermedia in education. From this pool, only 30 studies published between 1990 and 1996 met the minimal criteria of scientific merit for inclusion in the literature review. Their in-depth analysis of these 30 research reports yielded the following major conclusion: "Clearly, the benefits gained from the use of hypermedia technology in learning scenarios appear to be very limited and not in keeping with the generally euphoric reaction to this technology in the professional arena" (p. 345).

In a similar review, Fabos and Young (1999) critiqued the research on telecommunications in the classroom and concluded:

Telecommunications exchanges are lauded by educational researchers and industry experts for enhancing writing and collaboration skills, increasing multicultural awareness, and expanding future economic possibilities. As we have seen, however, many of these expected benefits are inconclusive, overly optimistic, and even contradictory. Like much scholarship on educational technology, many researchers are quick to enter discussions about skill, social, and economic benefits without considering the scholarly, historical, or industrial context of their claims. With regard to skills, we need to extend the discussion of telecommunication exchange projects from overgeneralized and often nebulous claims about skill benefits, and focus on the content of particular projects, why they hold promise, and how they can be used to meet specific educational goals.... While distance learning activities may appear to be magical education experiences, all educators must first step back, critically evaluate the inevitably enthusiastic rhetoric, and attempt to understand the complex contextual framework behind the push for telecommunication exchange. (p. 254)

What are teachers, who are encouraged to integrate hypermedia modules into their K-12 lesson plans, or faculty members, who are pushed to develop Web pages for university courses, to do with the conclusions reached by Dillon and Gabbard (1998) and Fabos and Young (1999)? Frankly, it is highly unlikely that these literature reviews will ever be read by practitioners, so such a question will go unanswered.

Clarifying the goals of research in interactive learning systems

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Researchers investigating interactive learning systems, especially novices, appear to have difficulty distinguishing between research goals and research methods. Evidence of this confusion is seen when a novice researcher states that he/she is only interested in conducting quantitative

(or alternatively qualitative) studies without specifying the type of research goal he/she is pursuing. The research goals held by any given researcher are influenced by many factors, including the epistemological views of the investigator, his/her research training, and the dominant research paradigms within his/her line of inquiry. Six major types of research goals commonly pursued by educational technology researchers are described in the following paragraphs.

Theoretical goals

Researchers with theoretical goals are focused on explaining phenomena through the logical analysis and synthesis of theories, principles, and the results of other forms of research such as empirical studies. This type of research is relatively rare because it requires levels of synthesis, generalization, and theory construction for which most researchers have not been prepared. In addition, this type of research usually requires a long-term scholarly agenda that can be sustained for many years. One example of research with theoretical goals within the field of educational technology is the seminal work of Gagné (1997) to describe the basic conditions of learning and a theory of instruction.

Predictive goals

Researchers with predictive goals are focused on determining how education works by testing conclusions related to theories of teaching, learning, performance, assessment, social interaction, instructional design, and so forth. Researchers with this type of goal usually employ experimental (or quasi-experimental) methods to determine or predict the effects of some form or aspect of a technological innovation under controlled conditions. This type of research has dominated instructional technology for decades, but reviews reveal that it is often done poorly (Reeves, 1993). Its popularity stems from the fact that, until recently, it was the only goal graduate students and young researchers were encouraged to pursue. In addition, predictive studies using quasi-experimental methods take less time and logistical support than other approaches, and many research journals are more receptive to reports of predictive studies than other forms of research. Although most studies of this kind are flawed, there are examples of good predictive research, such as the investigation of cooperative learning and learning control conducted by Hooper, Temiyakam, and Williams (1993) and the investigation of the influence of emotions and intentions on performance in a Web-based learning environment carried out by Martinez and Bunderson (2000).

Interpretivist goals

Researchers with interpretivist goals are focused on portraying how education works by describing and interpreting phenomena related to teaching, learning, performance, assessment, social interaction, innovation, and so forth. Learning systems researchers with interpretivist goals draw upon naturalistic research traditions borrowed from other sciences, such as anthropology and sociology. The popularity of conducting research from an interpretivist perspective has increased dramatically among educational researchers over the past 20 years, although this trend has not been as evident among educational technologists until recently. A backlash against qualitative research seems to be developing in some circles. *The Chronicle of Higher Education* cover story about educational research mentioned above (Miller, 1999) was especially critical of qualitative research for “yielding little that can be generalized beyond the classrooms in which it is conducted.” “Too much useless work is done under the banner of qualitative research” said an expert interviewed for the article. A pioneering example of interpretivist research within the educational technology field is Neuman’s (1991) naturalistic observations of learning disabled children using commercial courseware. A more recent example is Orrill’s (2001) qualitative study of teachers as their professional development framework evolved with respect to building technology-based, learner-centered classrooms.

Postmodern goals

Researchers with postmodern goals are focused on examining the assumptions underlying contemporary educational programs and practices with the ultimate aims of revealing hidden agendas and/or empowering disenfranchised minorities. Although it is increasingly conducted by researchers with strong multicultural, gender, or political interests, research in the postmodern tradition is very rare within the educational technology field. There are several reasons for this, not the least of which is the fact that there are relatively few educational technologists capable of mentoring graduate students or young researchers in this approach. Also problematic is the difficulty postmodern researchers have in finding scholarly outlets for their papers. De Vaney’s (1998) analysis of the field of educational technology in relation to race, gender, and power is a rare example of research with a postmodern perspective in this field.

Development goals

Researchers with development goals are focused on the dual objectives of developing creative approaches to solving human teaching, learning, and performance problems while at the same time constructing a body of

design principles that can guide future development efforts. Development research, which is also referred to as design experiments or formative research, has recently received endorsements from leaders in the field of educational technology (Richey & Nelson, 1996). Van den Akker (1999) identifies a significant characteristic of development research as focusing on “complex, innovative tasks for which only very few validated principles are available to structure and support design and development activities” (p 7). One example of development research is the long-term agenda of the Cognition and Technology Group at Vanderbilt (1992) aimed at developing innovative solutions to complex mathematics and reading problems, while at the same time building theoretical models, such as “anchored instruction.”

Action goals

Researchers with action goals are focused on a particular program, product, or method, usually in an applied setting, for the purpose of describing it, improving it, or estimating its effectiveness and worth. Sometimes called action research or evaluation research, research with action goals is similar to development research except that there is often little or limited effort to construct theory, models, or principles to guide future design initiatives. The major goal is solving a particular problem in a specific place within a relatively short timeframe. Some purists maintain that this type of inquiry is not research at all, but merely a form of evaluation. However, despite its primary focus on considerations of use for local practitioners, it can be regarded as a legitimate form of research, provided reports of it are shared with wider audiences who may themselves choose to draw inferences from these reports much as they would from reports of interpretivist research. One example of this research is an evaluation of a project-based undergraduate engineering course conducted by Reeves and Laffey (1999).

Selecting research methods

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In evaluation, methods should not be selected until the evaluator is clear about the decisions and questions to be addressed. Similarly, research methods should not be selected until a researcher is clear about his/her research goals as well as the nature of the research questions to be addressed within a particular study. Educational researchers who identify themselves as quantitative researchers or qualitative researchers are somewhat misguided; this is analogous to builders identifying themselves as hammer carpenters or saw carpenters. Research methods are tools, and tools should only be selected once goals and tasks are clear.

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More information about research methods is at: <http://trochim.human.cornell.edu/>

There are more research methods than can possibly be described in this chapter. However, Figure 12.2 presents a simple taxonomy of six categories of research methods that can be used by educational technology researchers to address a range of research goals. It must be stressed that there is definitely not a one-to-one relationship between these six types of methods and the six research goals identified above. However, some types of goals tend to be addressed with specific types of methods, e.g., researchers with postmodern goals often employ critical theory methods. Other types of methods, e.g., literature review, are used by researchers with diverse goals.

Quantitative	experimental, quasi-experimental, correlational, and other methods that primarily involve the collection of quantitative data and its analysis using statistics, e.g., the analysis of variance in exam results among students in traditional courses and Web-based courses
Qualitative	observations, case-studies, interviews, and other methods that involve the collection of qualitative data and its analysis using ethnographic approaches, e.g., participant observation in a Web-based course
Critical Theory	deconstruction of “texts” or the technologies and systems that deliver them through the search for binary oppositions, hidden agendas, and disenfranchisement, e.g., a critical analysis of the “digital divide”
Historical	an objective and accurate reconstruction of the past based upon analysis of historical documents, interviews, etc., often in relation to the tenability of a hypothesis, e.g., that John Dewey was the originator of progressive education
Literature Review	various forms of research synthesis that primarily involve the analysis and integration of other forms of research, e.g., frequency counts and meta-analyses, often yielding support for a specific thesis, e.g., computer-based tutorials are most effective with less capable learners
Mixed-methods	research approaches that combine a mixture of methods, usually quantitative and qualitative, to “triangulate” findings, e.g., a pre-test, post-test quasi-experimental design integrated with classroom observations

Figure 12.2. Six types of research methods used by educational technologists.

Development research as “use-inspired basic research”

As noted above, Stokes (1997) called for more “use-inspired basic research” rather than either pure basic or applied research. “Use-inspired basic research” for educational technology researchers is what others have labeled “development research” (van den Akker, 1999), “design experiments” (Brown, 1992; Collins, 1992), or “formative research” (Newman, 1990). The critical characteristics of “design experiments,” as described by Brown (1992) and Collins (1992) are:

- addressing complex problems in real contexts in collaboration with practitioners;

- integrating known and hypothetical design principles with technological affordances to render plausible solutions to these complex problems; and
- conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles.

Van den Akker (1999) states that, “Methods of development research are not necessarily different from those in other research approaches” (p. 9). Although this is usually the case, there are major differences between the philosophical framework and goals of these different approaches. Figure 12.3 illustrates the differences between research conducted with empirical goals and that inspired by development goals.

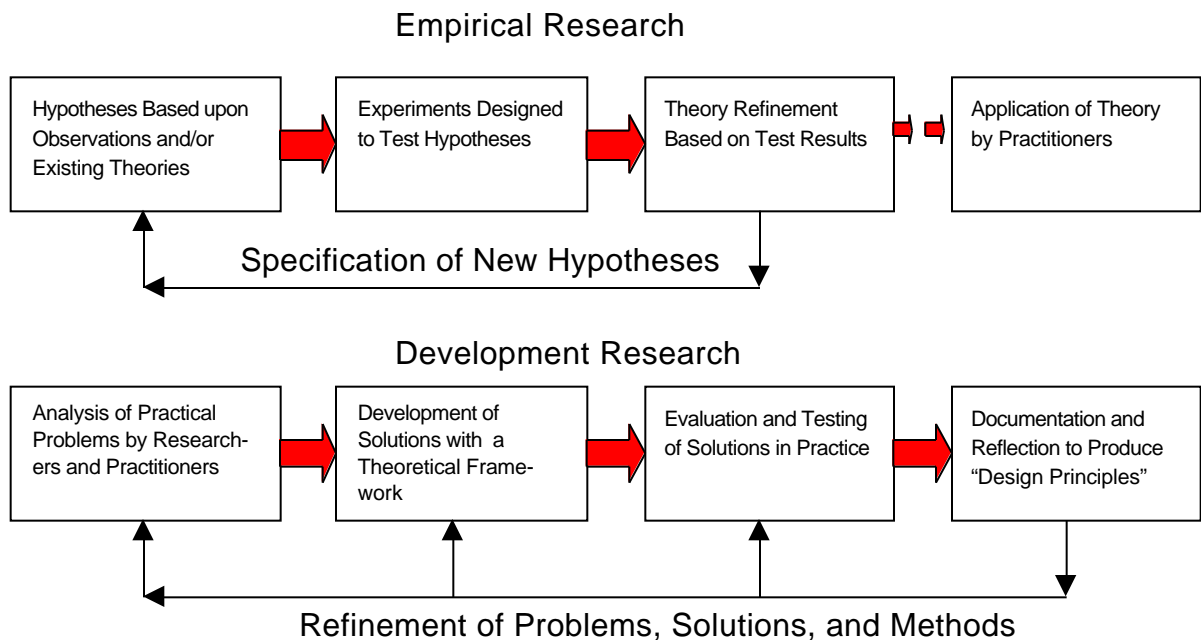


Figure 12.3. Empirical and development approaches to research in learning technologies.

Van den Akker clarifies the differences illustrated in Figure 12.3:

More than most other research approaches, development research aims at making both practical and scientific contributions. In the search for innovative ‘solutions’ for educational problems, interaction with practitioners...is essential. The ultimate aim is not to test whether theory, when applied to practice, is a good predictor of events. The interrelation between theory and practice is more complex and dynamic: is it possible to create a practical and effective intervention for an existing problem or intended change in the real world? The innovative challenge

is usually quite substantial, otherwise the research would not be initiated at all. Interaction with practitioners is needed to gradually clarify both the problem at stake and the characteristics of its potential solution. An iterative process of ‘successive approximation’ or ‘evolutionary prototyping’ of the ‘ideal’ intervention is desirable. Direct application of theory is not sufficient to solve those complicated problems. (pp. 8-9)

As illustrated in Figure 12.3, the influence of traditional empirical approaches to educational research on practice is based upon the optimistic assumption that practitioners can or will apply the theories derived from empirical investigations. If the theories have any merit, the persistence of significant problems in education suggest that this optimism is misplaced and that practitioners must be more directly engaged in the conduct of educational research. A basic tenet of development research is collaboration among practitioners, researchers, and technologists.

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Good examples of development research are difficult to find. The development activities of Jan Herrington and her colleagues at Edith Cowan University in Australia (Herrington & Knibb, 1999; Herrington & Oliver, 1999) are rare exemplars. In a doctoral dissertation study that won the 1999 Young Researcher of the Year Award from the Association for Educational Communications and Technology (AECT), Herrington used a range of innovative investigative strategies, including video analysis of the dialogue between pairs of students engaged in multimedia learning. Her collaborators in this long-term effort to develop and apply a model of situated learning theory included other educational technologists, math educators, and teachers. She not only developed a model of the critical factors of situated learning and instantiated these factors in multimedia learning environments, but she tested the model and the technological products in multiple contexts, including pre-service teacher education courses and K-12 schools. The research had value within the immediate context of its implementation, but also has yielded generalizable design principles. Her research agenda is still evolving, most recently focusing on the effectiveness of authentic activities in Web-based learning environments (Herrington, 2002).

Another fundamental tenet of development research is dedication to providing benefits to all stakeholders within the context of the research. Universities long ago established Human Subjects Review Boards to insure that researchers protect the welfare of the individuals who participate in their studies. Within a design science such as educational technology (and within education as a whole), we must go beyond concerns for the protection and safety of human subjects to examine the benefits to be derived from a particular line of research. A Human Benefits Review Board should review research plans with the intent of insuring

that the research has some reasonable potential for solving problems that diminish the quality of life for individuals and groups. This is especially important within taxpayer-supported public research universities.

Such a proposal is likely to lead to protests among those who put academic freedom above all other concerns, including social responsibility. Critics will proclaim that without the right to pursue research independent of considerations of practical value, many of the most important discoveries in fields such as physics, chemistry, biology, and medicine would never have been made. We agree, and therefore would not support a Human Benefits Review for research in those fields. But education is a fundamentally different type of science, if it is a science at all, and educational researchers have never produced discoveries analogous to those in the physical and biological sciences. Educational researchers must confront the sterility of their labors and take radical steps to conduct inquiry in more productive ways. However, we do not agree with the call for more randomized controlled trials of educational interventions issued by the Coalition for Evidence-Based Policy (2002).

The prospects for change in research approaches

The history of research in interactive learning systems suggests that it is time to give graduate students and young researchers the guidance and support they need to pursue development goals that have been neglected in our field for too long. Decades of experimental research with theoretical or predictive goals have provided an insufficient foundation of theories and principles to guide practice, whether in K-12 schools, higher education, business training, or any other learning context.

Is development research the only viable approach to research related to interactive learning systems? Perhaps not, but there is little evidence that the increasing popularity of qualitative methods will improve the impact of the research on practice, especially given that the proponents of qualitative approaches make few claims to generalizability. Although research conducted from a postmodern perspective may alert educators and the public at large to the injustices inherent in various educational innovations, ultimately this line of research will be as sterile as interpretivist research with respect to improving the conditions for teaching and learning with technology. After all, postmodernists denounce the prescription of technical solutions to complex problems as misguided modernist thinking. Action research is and will continue to be important within local contexts, but it is too weak for solving more complex problems. Given the poor history of other approaches, we are increas-

ingly convinced that if educational technologists want to contribute to meaningful educational reform, they should pursue development goals.

Of course, the probability of the establishment of a Human Benefits Review Board or the implementation of other radical reforms is extremely unlikely within today's academic climate. We can argue that educational technologists have a moral responsibility to pursue more development research, but the current focus on research for publication's sake will not change unless the reward systems in higher education are changed fundamentally, or unless the public demands more on the part of university faculty in terms of their productivity (Middaugh, 2000).

What can practitioners engaged in the development, implementation, and evaluation of interactive learning systems do with respect to advancing the state of design knowledge in the field of educational technology? Researchers with development goals focus on complex problems critical to human learning and performance. This type of research agenda requires intensive collaboration among researchers and practitioners. Rather than sticking to one preferred method, development researchers select methods as tools to accomplish specific tasks, and they engage in continual refinement of research protocols. There is considerable overlap between these activities and the activities in which you may be engaged as an evaluator of interactive learning systems.

Development researchers are also committed to constructing design principles and producing explanations that can be widely shared. This is not an activity in which practitioners typically engage. But there is little reason why you cannot take some time away from the hectic whirl of production schedules and evaluation activities to reflect upon what you have learned and how you might share "lessons learned" through presentations and publications. You don't have to be a university professor to produce evidence and ideas that are worth sharing with other professionals. After all, the best educational technologists are reflective and humble, cognizant that their designs, evaluations, and conclusions are tentative in even the best of situations.

Designers and evaluators of interactive learning systems who make time to engage in development research should share the results of their design experiments in multiple ways, including refereed and commercial publications, Web pages, conferences, and workshops. If you take up our challenge, you can expect to work a little harder. But we are confident that the long-term rewards with respect to your own professional development, as well as the general advancement of the field of educational technology, will make it all worthwhile.

Conclusion

Moving the educational technology community toward development research will not be easy because it requires fundamental changes in our epistemology and our mental models of the research process. It requires what Thomas Kuhn (1970) identified as a paradigm shift. Educational technology research and evaluation has long been dominated by positivist epistemology that regards learning theory apart from and above educational practice. The overall goal of research within the predictive tradition is to develop long-lasting theories and unambiguous principles that can be handed off to practitioners for implementation. Development research, on the other hand, requires a pragmatic epistemology that regards learning theory as being collaboratively shaped by researchers and practitioners. The overall goal of development research is to solve real problems while at the same time constructing design principles that can inform future decisions. In Kuhn's terms, predictive research and development research are different worlds.

Adding a reflective, development research orientation to your work as an instructional designer, project manager, or evaluator within the context of interactive learning systems may not require anything as dramatic as a paradigm change. But we believe that it can enhance your own professional development and the work that you and your colleagues accomplish. In addition, we are convinced that over time, such an orientation can contribute to the design knowledge upon which future advances in the educational technology field will be based. Stokes (1997) describes how Pasteur's research, although conducted in the context of solving practical problems, led to major advances in several fields. We may not attain the level of Pasteur's enormous impact, but together we can advance the state-of-the-art, and perhaps even the science of our field.

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