

Enhancing the Worth of Instructional Technology Research through “Design Experiments” and Other Development Research Strategies

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Introduction

Several years ago, Professor Dave Merrill from Utah State University drew a metaphorical line in the sand that called for anyone committed to serious instructional 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). He also contended that instructional design is a technology derived from the science of instruction based upon principles that could be verified by empirical data.

Not everyone in or out of academe shares Professor Merrill’s positive assessment of instructional design as a scientifically valid technology. Consider the following quote from Professor Lauren Resnick from the University of Pittsburgh. (These remarks were made at the 1999 AERA Meeting 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. Unfortunately, the debate about the value of instructional technology as a field 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.” Reflecting similar doubts, Dr. Bob Kozma of SRI, serving as a discussant for a session on applications of instructional theory and design in technology at the AERA conference in Montreal 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 such controversies today. 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 instructional technology (IT) research 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 IT 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). Another controversy concerns whether instructional technologists should conduct basic research to build generalizable theories or pursue applied research to solve specific problems.

Problems with Instructional Technology Research

Calling attention to problems with instructional technology research has occupied various scholars for decades (e.g., Clark, 1983; Hoban, 1958; Mielke, 1968), but many problems persist. At the risk of sounding yet another call for reform that may never come, three significant problems with IT research are highlighted below. First, major misunderstandings exist among instructional technologists about the differences between basic and applied research. Second, the quality of published research in the field of instructional technology is generally poor (although no poorer than educational research in general). Third, syntheses of instructional technology research, such as literature reviews and meta-analyses, provide practitioners with insufficient or confusing guidance.

Basic Versus Applied Research

Most instructional technologists, 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 instructional technologists, there have long been arguments about the relative value of basic versus applied research (cf. Merrill et al., 1996). Evidence of the debate 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 (Higgins, Sullivan, Harper-Marinick, & López, 1989). Some instructional technologists appear to have great commitment to basic research, regardless of whether it has any practical value, perhaps because basic research seems more scientific or they believe that it is someone else’s role to figure out how to apply the findings of basic research. Others seem to believe that the value of basic research in a design field such as IT is limited and that IT research should therefore have direct and clear implications for practice.

More thoughtful reflection suggests 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 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 the 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 the 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.

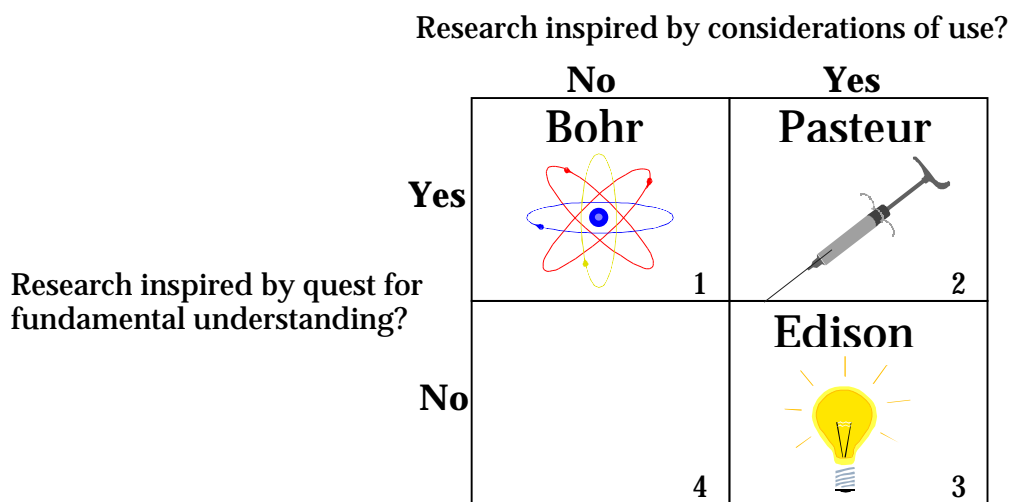


Figure 1. Pasteur's Quadrant View of Research (Stokes, 1997).

Although Stokes (1997) left quadrant 4, research that neither seeks fundamental understanding nor considers use, blank, much of research conducted by instructional technologists (as well as by other educational researchers) 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 I first came to The University of Georgia in 1982, several professors in the College of Education advised me to get my hands on a large set of data so that I could mine it for multiple publications. Hardly any one pointed me 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 paper, wrote to tell me 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 scientific research.

Poor Quality of Educational Technology Research

Although more instructional technology researchers appear to be adopting qualitative or mixed methodologies than 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 the extant body of IT research. Unfortunately, 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). The PCAST panelists failed to explain how more 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).

The sources of the bulk of instructional technology research are 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 and/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.

In view of what some may interpret as an overly harsh critique of instructional technology research, it is important to point out that educational research in general is deserving of the same criticisms. 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 twenty years of my academic career, I had occasionally seen similar titles for articles published in *Educational Researcher* and other education publications (cf. 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. It stings to see educational research at large condemned for its lack of substance and influence in such a public manner. But to ignore such critiques is irresponsible.

Disappointing Research Syntheses

Given the poor quality of the inputs to research syntheses in the field of instructional technology, it is little wonder that the literature reviews and meta-analyses in IT yield disappointing results that provide practitioners with insufficient or 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 (Kulik & Kulik, 1991).

The problems with instructional technology research were demonstrated in two recent literature reviews published in the *Review of Educational Research*, a highly-respected publication of the American Educational Research Association (AERA). 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 (1998) 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, 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 distant 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)? Of course, 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 Instructional Technology Research

One of the primary problems many IT researchers, especially novices, have is 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 IT 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 instructional 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.

Empirical Goals

Researchers with empirical 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. IT researchers with this type of goal usually employ experimental (or quasi-experimental) methods to determine 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 (cf. 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, empirical studies using quasi-experimental methods take less time and logistical support than other approaches, and many research journals remain more receptive to reports of empirical studies than other forms of research. Although many such studies are flawed, there are examples of quality research such as the investigation of cooperative learning and learning control conducted by Hooper, Temiyakarn, and Williams (1993).

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. Instructional technologists 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 instructional 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 instructional technology is Neuman’s (1991) naturalistic observations of learning disabled children using commercial courseware.

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 increasingly evident among researchers with strong multicultural, gender, or political interests, research in the postmodern tradition is very rare within the IT field. There are several reasons for this, not the least of which is the fact that there are relatively few instructional technologists capable of mentoring graduate students or young researchers in this approach. Another 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 IT research with a postmodern perspective.

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 several leaders in the field of educational technology (cf. 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 little or no 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 theorists 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 in a sense similar to 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).

Instructional Technology Research Methods

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 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.

There are more research methods than can possibly be described in this paper. However, Figure 2 below presents a simple taxonomy of six categories of research methods that can be used by instructional technology researchers to address a range of research goals. It must be stressed that there is 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.

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, 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.
Mixed-methods	research approaches that combine a mixture of methods, usually quantitative and qualitative, to "triangulate" findings, e.g., a pre-test, post-test design integrated with classroom observations.

Figure 2. Six types of research methods used by instructional technologists.

Development Research as "Use-Inspired Basic Research" in IT

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 instructional technologists is what is labeled "development research" (van den Akker, 1999), "design experiments" (Brown, 1992; Collins, 1992), or "formative research" (Newman, 1990). I personally prefer the term, design experiments, as originated by Ann Brown (1992) and Alan Collins (1992). They defined critical characteristics of design experiments as:

- 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.

Good examples of design experiments and other forms of development research are difficult to find. The development work of Jan Herrington and her colleagues at Edith Cowan University in Australia (cf. Herrington & Knibb, 1999; Herrington & Oliver, 1999) is a rare exemplar. Herrington used a range of innovative investigative strategies, including video analysis of the dialogue between pairs of students engaged in multimedia learning, in a doctoral dissertation study that won the 1999 Young Researcher of the Year Award from the Association for Educational Communications and Technology (AECT). Her collaborators in this long-term effort to develop and apply a model of situated learning theory included other instructional 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.

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 3 illustrates the differences between research conducted with traditional empirical goals and that inspired by development goals.

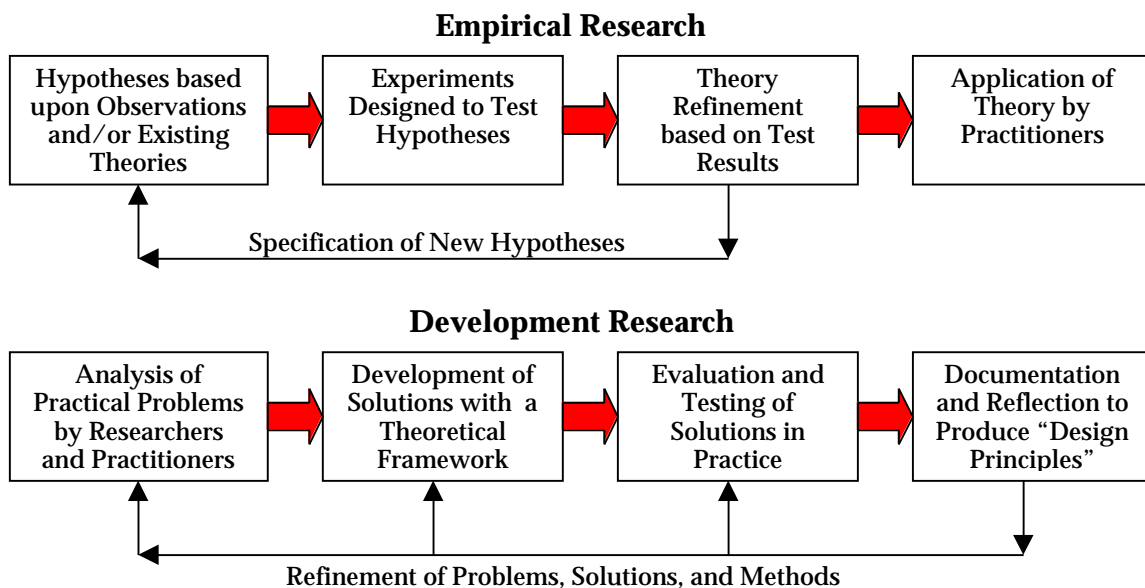


Figure 3. Empirical and development approaches to IT research.

Van den Akker clarifies the differences illustrated in Figure 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 3, the influence on practice of traditional empirical approaches to educational research 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 and training suggest that this optimism is misplaced and that practitioners must be more directly engaged in the conduct of educational research. A fundamental tenet of development research is collaboration among practitioners, researchers, and technologists.

Another fundamental tenet of development research is the dedication to providing direct benefits to all stakeholders within the context of the research. Universities and other institutions long ago established Human Subjects Review Boards to insure that researchers protect the welfare of the people who participate in their studies. Within a design science such as instructional 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 the research has some reasonable potential for solving problems that detract from the quality of life for individuals and groups in society. 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 such as social responsibility. These critics will proclaim that without the right to pursue basic research without any considerations of practical value, many of the most important discoveries in fields such as physics, chemistry, biology, and medicine would never have been made. I agree, and therefore I 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 even remotely analogous to those in the physical and biological sciences. Educational researchers must confront the sterility of their past labors and take radical steps to conduct inquiry in more productive ways.

The Prospects for Change in Instructional Technology

The history of IT research 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 instructional technology research with theoretical or empirical goals have provided an insufficient foundation of theory and principles to guide practice, especially in K-12 schools, higher education, business training, or any other learning context.

Is development research the only viable approach to IT research? Perhaps not, but there is little evidence that the increasing popularity of qualitative methods will improve the impact of IT 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 impotent 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, I am increasingly convinced that if instructional technologists want to contribute to meaningful educational reform, they should pursue development goals.

Of course, the probability of establishing a Human Benefits Review Board or other radical reforms (such as the elimination of tenure that drives so much of the pseudoscience among educational researchers) is extremely unlikely within today's academic climate. Therefore, it must suffice to argue that instructional technologists have a moral responsibility to pursue more development research. Researchers with development goals focus on broad-based, 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. Development researchers are also committed to constructing design principles and producing explanations that can be widely shared. Instructional technologists engaged in development research are above all reflective and humble, cognizant that their designs and conclusions are tentative in even the best of situations.

Although it is easy to advocate development research., I would not be honest without acknowledging its difficulties. The duration of treatments involved in the past fifty years of instructional technology research have often been sixty minutes or less (Clark 1983; Reeves, 1993). Development research treatments, by contrast, are likely to last many days, weeks, or months. Rather than requesting permission to come into a classroom or training center for a few hours, instructional technology researchers and practitioners should enter into long term agreements to build prototype solutions together and study them rigorously. Funding agencies, whether government or private, must be prepared to support these collaborations for five years or more to expect useful results. None of these activities will be easy.

A commitment to development research may also put careers at risk. I believe that most IT researchers desire to focus their research on more important problems, but knowing that their work is ultimately judged by tenure and promotion committees on the basis of quantity rather than quality, they are compelled to take the path of least resistance and conduct whatever studies yield the most publications. In my own university, a few

faculty members have pursued scholarly agendas aimed at developing and testing educational innovations or reforms in local schools. These people have primarily published practical papers in practitioner-oriented (non-refereed) publications, and although they may have conducted socially responsible research, some of them have perished academically or failed to receive the promotions I believe they deserve.

Perhaps these academic researchers would have been more successful if they had adhered to all of the following heuristics for instructional technologists who wish to engage in development research:

- Focus on chronically difficult problems related to human learning and performance.
- Engage teachers, students, and colleagues in long-term collaborative research agendas.
- Carefully align any prototype technological solutions with instructional objectives, pedagogy, and assessment.
- Clarify the theoretical and practical design principles that underlie prototype technological solutions, and conduct rigorous studies of these principles, their inherent assumptions, their implementation, and their outcomes in realistic settings.
- Share the results of your design experiments in multiple ways, including refereed and commercial publications, web-pages, conferences, and workshops.
- Expect to work very hard. Be patient and persevere. And enjoy the challenge and reward of a career worth having for its contributions to the greater good.

Conclusion

Moving the IT research community (as well as other educational researchers) 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. Instructional technology research has long been dominated by positivist epistemology that regards learning theory apart from and above instructional practice. The overall goal of research within the empirical 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, these are different worlds.

Kuhn cautioned that such a shift cannot be made step-by-step on the basis of logic, but requires a revolution, often laden with emotion. The German Physicist, Max Planck seemed to agree when he wrote that "a new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it." Hopefully, Planck was too pessimistic and the IT research community will see real reform in the near future. I, for one, do not believe that we can afford to lose another generation of researchers to the pursuit of research for its own sake.

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