more personal tack as Barab examines the role of instructional design and learning sciences research, utilizing stories from his own experiences as examples. Smith continues in the personal vein as he explores the themes of boundary crossing, terminology, methods, and history of these fields.

Responses are divided into two groups; those from the LS community and those from the IS community. Koschmann initiates the LS responses by examining the definitions and consequences of names such as "Learning Sciences" and of applying these names to both fields of study and research communities. Edelson adds his own historical perspective on the emergence of the learning sciences field and discusses the efficiencies and inefficiencies associated with the separation of these communities. Two dymanics emerge clearly from Scardamalia's characterization of the position papers; the dynamic of theory vs. design and the dynamic of culture vs. technology. Kolodner offers a particularly colorful historical perspective on the emergence of the learning sciences field with directions for future development from the LS perspective and ways that this development can include instructional design.

The IS responses begin with a close analysis of the position papers in which Carr-Chellman brings forward deeper understandings of key concepts, such as science, technology, and design as used by the two communities. A close textual examination of the papers is continued by Merrill, who reiterates the scientific foundations of instructional design. Spector questions whether a division actually exists between the two fields and highlights other divisions, such as international and political concerns. Ragan and Smith Ragan likewise question whether we are in fact facing a "false dichotomy" and explore some common misinterpretations of the IS field. Finally, Reigeluth continues to make precise the definitions within the IS field, while highlighting the role of theories, goals, and design. □

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Learning and Design: Why the Learning Sciences and Instructional Systems Need Each Other

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Who studies educational technology? Many scholars, policymakers, and even parents are deeply interested in research on technologies for learning, but the question of where to turn for this research is surprisingly difficult to answer. In particular, there are two very active communities that both study more or less the same area, but these communities hardly talk to one another (Kirby, Hoadley, & Carr-Chellman, 2003). How can this be?

Research does not take place in a vacuum, nor does it occur in an idealized world of ideas and concepts. It takes place in a social world in which communities of scholars develop epistemologies, norms, shared conceptual frameworks, and bodies of literature. Disciplinary labels help institutionalize these communities, as do other kinds of labels, such as "schools" (e.g., "the Chicago school," "Continental philosophy," etc.) or professional societies. The most concrete manifestation of a research community is its products, such as conferences where knowledge is shared, and journals where work is published. Status is often indicated by control within the community, i.e., helping judge academic tenure cases, editing journals, reviewing funding proposals, and peer-reviewing articles.

The edges of research communities are not sharp, and thus there is often tumult at these edges—research communities may collide, or they may simply pass by

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one another, "agreeing to disagree." It is particularly fascinating when some important research question or problem forces a reorganization of these boundaries, a redistricting of academic disciplines or communities. It is precisely this sort of redistricting that is taking place in educational research, in particular related to technology for learning.

In this article, I discuss one relatively new research community, called learning sciences, and describe some of its unique features. I also examine some of the points of overlap and disconnect with another community traditionally concerned with educational technology, the instructional systems design community, and highlight some reasons I believe the two communities are and should be converging.

How Research Communities Differ

What sets one research community apart from another? Characteristics that distinguish communities may include their scope and goals, theoretical commitments, epistemology and methods, and their history.

Scope and Goals

Certainly, the most basic reason for the multiplicity of scientific research communities is that they may study different phenomena or have different goals. One would not expect paleobotanists and particle physicists to share a research community. (While there are large organizations, such as the American Association for the Advancement of Science, or publications, such as *Scientific American*, where these two groups might coexist, I would argue that these are not research communities in the traditional sense; that is, they would not regularly read each others' results, peer-review each others' papers, etc.) Likewise, one would not expect the astronautical research community and the astronomy community to be identical; while both study space and both might care about, for instance, cosmic radiation near the earth, they have (mostly) nonoverlapping goals of exploration beyond our planet vs. scientific understanding of large-scale natural phenomena in the universe.

Theoretical Commitments

Another distinction that may separate research communities is their grounding in different theories. For instance, quantum physicists have been somewhat segregated within the physics research community, based on their theoretical commitments; likewise, Freudian psychologists (and the psychoanalytic community in general) might participate in different communities than, say, developmental psychologists though both study human development over time.

Epistemology and Methods

Another way in which research communities differ is in their epistemological assumptions and commitments. This difference most often manifests itself in questions of method. Some differences run deep, such as the schism between naturalistic inquiry in human behavior (such as ethnomethodology) and experimental inquiry into human behavior (such as experimental psychology). Like oil and water, different deep assumptions rarely mix; in this example, leading to the boisterous and sometimes rancorous debates of "qualitative vs. quantitative methods." The root issue in these debates has not been whether one describes the world in countable or noncountable terms, but rather what the proper epistemology of inference is. A less profound difference in methods may also divide one community from another, for instance, psychologists who use neurological or medical imaging technologies to study cognitive processes vs. psychologists who use traditional psychometrics to study cognitive processes. Here, there may be broadly overlapping theoretical stances, but the pragmatics of research drive people to specialize in one type of data collection, and this may lead to different communities or subcommunities.

History

Intellectual differences alone (like scope, theories, or epistemologies and methods) do not explain how research communities differ, however. Research communities have, for instance, a pedigree or intellectual heritage; often they are offshoots of a discipline or community that came before. This pedigree is important to people in the community; it influences their notions of how to train people for participation in the community, who the respected founders are, and which institutions are "important." In some cases, accidents of history prevent research communities from being aware of each other, and different groups must replicate each others' work—this happens routinely due to geographic distance or linguistic barriers. One extreme example is the Indian mathematician Ramanujan who, working in isolation, reinvented work by Gauss and Kummer, since he never was able to complete university studies in his native India. He later joined a larger research community, when he finally entered communication with (and eventually joined) prominent mathematicians in England.

Thus, we see that some of the characteristics that help define and distinguish research communities are: the phenomena studied and goals, theoretical perspectives, epistemology and methodology, and historical context.

Communities Studying Educational Technology

Kirby *et al.* (2003) have documented that the learning sciences and instructional systems communities do not overlap very much. Let's examine why, using the framework above. Where do these two communities stand on scope, goals, theories, epistemology and methodology, and history?

Overlapping Interests in Educational Technology

With regard to scope, both the learning sciences and the instructional systems design communities encompass educational technologies, although with slightly different purposes. Instructional systems design is concerned with the best ways to create systems that yield learning. In the past, this has been primarily focused on the development of instructional materials, but in more recent years it has included organizational and systems-level factors that influence student learning. Technology is, of course, an important aspect of these systems, and the fact that two of three primary sources analyzed by Kirby *et al.* have the words "educational technology" in their titles is testament to the prominence of these terms. Learning sciences also encompasses the environments that surround people as they learn and change, including computers. In the initial issue of the *Journal of the Learning Sciences*, the editor, Janet Kolodner, discusses how "rather than trying to use computers to solve all of education's problems," the learning sciences "need[s] concrete guidelines about what kinds of educational environments are effective in what kinds of situations, and based on those guidelines, we need to develop more innovative ways to use computers." Both communities share educational technologies in their scope.

A Shared Goal Via Different Means

The goals of the two communities are difficult to consider in isolation from their theories and histories (an issue I return to later) but are two different spins on the same theme. Both are educationist (they want to foster learning in and out of schools) but have differing models of how this can be accomplished. This is the clearest intellectual distinction between the two fields: The instructional systems design field has a fundamentally design-oriented, and hence directly interventionist, stance, while the learning sciences has a goal of science in service of education—better theories and science leading to better interventions. As summed up so nicely by Reigeluth (1999a): "How to help people learn better. That is what instructional theory is all about. It describes a variety of methods of instruction... and when to use—and not use—each of those methods." Meanwhile, in the learning sciences (Kolodner, 1991), modeling learning (not instruction) is the core focus (much as educational psychology before it): "We simply do not have sufficiently concise theories of learning to be able to tailor curricula to the natural way kids learn," and "Addressing problems in both education and training requires us to develop models of learning in real-world situations. If we find out how people learn in natural situations, we can create educational environments more conducive to learning." At least on the surface, this would appear to be a large difference that might keep the communities apart—their goals (or at least their near-range goals) are different.

Converging Theories

Both communities have a variety of theoretical stances, but these seem to be converging. The tremendous sense of optimism and promise for technology to aid in learning has taken many forms over the years, and we seem to have added more and more models of why we care about technologies in education. Some variance in these models of what ed tech buys us stems from differences in learning theories: the behaviorist model of learning implies that learning technologies are conditioning devices, while instructionist theories of learning imply that learning technologies are new types of instructional media. Constructivism implies that learning technologies are essentially environmental support for learners constructing their own knowledge, and sociocultural theories of learning may look at technology as a cultural instrument for those who are entering communities of practice. Thus, one might expect there to be different communities of researchers based in each of the major learning theories.

Instructional systems design was originally rooted in an instructionist tradition, although this is changing (Snelbecker, 1999). Researchers such as Land (Land, 2000), Hannafin and Hannafin (Hannafin, Hannafin, Land, & Oliver, 1997), and Jonassen (Jonassen, 1990) have explicitly highlighted constructivism in instructional design models. In the learning sciences, constructivism is often taken for granted, but the debate is between cognitive (in the sense of information processing) and sociocultural versions of constructivism (for instance, see the debate in the journal *Cognitive Science;* Cognitive Science Society, 1993). So, although they do start from different theoretical perspectives, both are arriving at a similar perspective of constructivist learning.

Methods in Flux: What Do We Know?

The epistemologies and methodologies of both communities are, interestingly, both in flux. In the past, perhaps ten to 15 years ago, maintaining a distinction between "doers" and "users" of scientific research (Snelbecker, 1999) would have been a comfortable stance with members of both fields. Instructional designers might be more likely to do experimental studies to demonstrate efficacy of an intervention, while learning scientists might be more likely to do experiments to validate or invalidate a theory of learning, but the inferencing model was relatively positivistic. Both fields respected the knowledge-in-practice that designers (in the case of ISD) or teachers and computer scientists (in the case of LS) had. More recently, both fields have struggled with how "doers" and "users" may not be so separate after all (Robinson, 1998), a situation labelled in national policy discussions as "Pasteur's Quadrant" (i.e., research that is both applied and theory-driven; Stokes, 1994). In terms of inferencing, the nature of design knowledge has been foregrounded and explicitly compared to experimental and naturalistic ways of knowing (Design-Based Research Collective, 2003; Edelson, 2002; Reigeluth, 1999b; Reigeluth & Frick, 1999). In this sense both fields are evolving methodologically.

Disparate Histories

What about each field's history with educational technology? Educational technology is arguably either a very new or a very old phenomenon, depending on one's view of what exactly "technology" comprises. In the largest, anthropological sense, technology is tools, whether it is a physical artifact (like a stick for digging for ants) or a cultural practice that helps people accomplish what they could not accomplish alone (like the Trobriand Islanders' technique for using the stars and imaginary islands to be able to navigate canoes across thousands of miles of open ocean; Hutchins, 1995). In this sense, educational technologies could include everything from textbooks to the Socratic method. The more modern sense today, and the one which implies that educational technology is a new phenomenon, is the notion of technology as information technology, and, in particular, networked information technologies such as personal computers connected to the Internet. Certainly, this type of technology has existed for decades (B. F. Skinner once wrote of the promise of computers for conditioning students to learn; Skinner, 1968) but the 1990s mark the beginning of the modern-day experience of computers as (relatively) affordable and available devices, almost infinitely programmable, capable of processing many kinds of media, and connected to a global network. The personal computer revolution plus the explosive growth of the Internet has transformed the role of information technology in our society dramatically over the last ten to fifteen years, and in this sense, educational technology is a "new" phenomenon to study.

Each of the two research communities has a different history of how they entered the educational technology arena. With instructional systems design, the addition of computer technologies was an extension of other instructional media that had come before for educational use, such as videodiscs, filmstrips, television, radio, and of course books. The field itself broadened its self-definition over the years, focusing more on systems for learning and less on instructional media per se (Reiser, 2001a, 2001b). Thus, the link from instructional systems design to educational technology was as an instrument for structuring instructional (or educational) experiences.

The learning sciences, on the other hand, began from a cognitive science perspective. Although technology was never part of the name of the field, it has always been associated with it. First of all, the name was founded by people such as Roger Schank at Northwestern University, who came to cognitive science from an artificial intelligence (AI) perspective. AI occupied a strange place between computer science and psychology, and researchers used artificial intelligence systems both as an engineered support for human performance and as psychological models that could be tested for fidelity to human psychology (J. Anderson, Boyle, & Reiser, 1985; J. R. Anderson, Farrell, & Sauers, 1984).

The first International Conference of the Learning Sciences was originally intended to be an Artificial Intelligence in Education conference, and although the stated topic was cognition in learning and how to support it, technology was present in many of the papers presented. Another injection of technology into the learning sciences was driven by the home fields of researchers in the area. Recall that from the beginning the learning sciences espoused studying cognition in learning contexts. While some learning scientists were cognitive scientists working in fields like literacy education (Palincsar & Brown, 1984), a large number either came from or ended up working on problems related to mathematics, science, and engineering education. A quick search of the *Journal of the Learning Sciences* in the *Current Contents* database from 1991–2001 showed that 32 of 96 articles were cataloged using the keywords science education, physics, chemistry, biology, mathematics, or engineering. While only ten of 96 articles in the *Journal of the Learning Sciences* had words like multimedia, technology, or computers in the title, 51 had these words somewhere in the record.* I suspect a detailed survey of authors would reveal that many had been trained in or worked with science, technology, engineering, and math (STEM) disciplines in which computer use was prevalent, and this may be the reason that technology was seen as a component of the learning environment from the beginning of the learning sciences field. As a

*This search was performed using the word stems "*media*", "*technol*", and "*comput*" and three references were manually eliminated where the only match was words like "immediate" or "intermediate"; one reference was manually eliminated where the only match was the author affiliation (MIT Media Lab). The keyword search included all fields including library-assigned subject headings as well as abstracts, titles, etc.

concrete example, the Institute for the Learning Sciences at Northwestern is affiliated with the computer science department. Thus, the histories of both fields have included technology, but via different paths.

To sum up, when one considers scope, goals, theories, epistemology and methodology, and disciplinary history, there are many points of overlap, but many differences as well, between the instructional systems design field and the learning sciences. The two fields have overlapping scope, converging theories, and very different histories. But the areas of goals and epistemologies and methodologies are changing rapidly. Do these fields have a future together in studying educational technology? I argue below that, because of developments in design-based research methods, they do.

Moving Forward: Design and Research

Few issues in academia generate heated debate the way methodology does. In general, epistemological and methodological assumptions underlie generations of research and are remarkably stable over time. As pointed out by Thomas Kuhn (1965), scientific revolutions—i.e., anything that calls into question the prior paradigm and forces reinterpretation of prior understandings—are painful, infrequent, and deeply resisted. Educational researchers are currently experiencing the beginning of such a revolution.

Sometimes methodological battles have no clear winners; the "qual vs. quant" wars yielded an uneasy *detente* in social sciences, with both sides coexisting but muttering over the lax standards of the other. Of course, the issue isn't whether things are categorized or counted, but whether the underlying epistemology is an experimental one or naturalistic. Experimentalists assume that controlled experimentation is the only legitimate way to make causal inferences, which depends on two key assumptions: universality (that the laws of the universe are stable and universal) and replicability (that experiments can be described in such a way that the procedures can be repeated, with equivalent outcomes). Naturalistic research, based more in ethnographic methodologies, views social context as a fleeting and local, but central, component of human behavior, and highlights the difficulty of any researcher interpreting the experiences of others without being grounded in the particular context.

Both have sophisticated ways to ensure rigor, but these methods address different concerns. Experimentalists treat quantitative analysis and experimental design as problematic, whereas the link between treatments and theory, or outcomes and theory, is unproblematic. Rigor often manifests itself as attempts to eliminate experimenter bias, account for and minimize measurement error, or ensure adequate controls on treatment conditions. For a naturalistic qualitative researcher, the focus is more on problems of grounding and interpretation. Researcher bias is a *given* that must be managed and exposed, not eliminated, because each person's perspective is presumed to underlie their interpretations of events. Interpretation is a central problem of rigor, since the researcher is never grounded in the context in exactly the same way the participants being studied are. Generalization is highly problematic (how can one person's lived experience match another's?).

This schism has roots that go deep into the history of educational research. Ellen Lagemann, a historian and former chair of the National Academy of Education, has documented how the founding of educational research in general struggled with some of these issues (Lagemann, 2000). At odds were the behaviorists, who wanted to perform an educational science that looked like physics, leading to some sort of Newton's laws for learning; and those who wanted to study learning in real contexts, embedded in practice, such as Dewey. Dewey highlighted how experimentation with educational/instructional strategies could be helpful, but maintained the need to have this work informed by practitioners with knowledge of the local context, and hence created the University of Chicago lab school (Dewey, 1896, 1929). Currently, education research is in a crisis, in that it is not respected and is viewed by many as a failure. Some judge the field based on its lack of resemblance to the "hard" sciences, while others complain of its irrelevance to questions of educational practice (Kaestle, 1993; National Commission on Excellence in Education, 1983; National Research Council, 2002). Lagemann suggests this was due to happen from the start because the expectations placed on education research to be "scientistic" were unreasonable. The core questions of how to reconcile contextualized practice and generalizable research were never completely resolved.

Research and Design in ISD and LS

Researchers in both instructional systems design and learning sciences are, in Dewey's terms, *educationists.* In general both groups seek to improve the lot of students or learners. However, their approach to doing so has kept research and design separate. Learning scientists set out to uncover basic scientific principles which would then be applied to instruction. Instructional designers sought to apply theory to the problems of instruction, and systematize the processes that took theories and turned them into educational environments. Robinson (1998) argues that this model of research leading to application is flawed, at least sometimes. In practice, it is quite difficult to apply theories to learning when the theories are incomplete or may be modulated by constraints from the local context. Likewise, and perhaps less intuitively, "pure" scientists in education often discover that testing theories involves significant amounts of design work, and that it is quite hard to take a theoretical concept such as "problem-based learning" or "anchored instruction" and create a treatment which adequately represents the theory for testing *in a particular context.* Science and design are not so cleanly split.

Design-Based Research: Bringing Worlds Together

In the early 1990s, a number of prominent researchers, identified with the learning sciences, began to describe a methodology that involved doing scientific inquiry through the process of designing learning environments for particular contexts. Initially this type of work was termed "design experiments" (Brown, 1992; Collins, 1992). Within learning sciences, this work did not cause the discomfort it would have in education research at large, because the learning sciences were accustomed to the methodological and epistemological diversity present in cognitive science. The basic idea seemed sensible: use iterative design of learning environments to explore what works, what's important, and how it relates to learning theory. However, this approach generated some methodological backlash (e.g., Levin & O'Donnell, 1999). Indeed, the No Child Left Behind Act in the United States specifically defined scientific research to include experimental and quasi-experimental work only. Yet, design-based research continues to be an important method by which people investigate phenomena in the learning sciences. Over the 1990s, groups within the learning sciences have continued to explore ways that design can be a mode of inquiry (Design-Based Research Collective, 2003; Edelson, 2002; Hoadley, 2002; Kelly, 2003).

In instructional systems design, a parallel question of how design may be theorized has been examined in roughly the same timeframe. In particular, Reigeluth and others have questioned the role of design and formative research as means to understanding (rather than merely implementing) learning (Barab, Squire, & Dueber, 2000; Merrill, 2002; Reigeluth, 1999b; Reigeluth & Frick, 1999). This question of "What can we learn from design?" has been asked in other areas of design as well, such as engineering and computer science (Argyris & Schön, 1991; Carroll, 1991).

As design-based research (and research-based design) becomes more prevalent in education in general (and educational technology in particular) the two fields of instructional systems design and the learning sciences will have more and more overlap in goals, methods, and epistemology. While the two fields do not have much shared history yet, this is changing. Individuals are starting to cross the boundaries between the two fields. For instance, Barab has discussed issues related to design and methodology in both the instructional systems community and learning sciences (Barab & Kirshner, 2001; Barab *et al.*, 2000). Penn State chose to hire two learning scientists (Brian Smith and myself) into their instructional systems faculty; Indiana University, a bastion of instructional systems, is launching a learning sciences program; Stanford University, a home of much learning sciences research, chose to add "Design" to the title of their new Learning Sciences doctoral program. As the two communities become more aware of each other, a shared history is likely to develop.

Potential Payoff: What ISD and LS Can Do Together

The confluence of fields can only improve our understanding of, and ability to implement, successful learning environments that include technology. As both sides cast about for ways to do research that is rigorous and respects the mutual influence of people, activities, and tools *in situ*, I believe design will take a central role. We would never expect architecture to develop a building design that works for everybody and every site. It is laughable to imagine this endeavor: federally funded, large-scale trials comparing House A to House B, with attempts to statistically control for relevant factors such as family size, socioeconomic status, and gender. Architects learn generalities about building design that they then can apply to particular contexts. This application is not simply following some recipe, but involves some metaknowledge about structuring design processes, and the use of expertise and intuition to tailor the generalities to the particular needs of the situation. We face a similar possibility in educational technology. The nature of design knowledge—the idea that it can be about many contexts while implying some sort of customization or application for each individual setting—suggests that we need to be training a new generation of educational technologists who can blend research and design. It is only when our models of learning are just general enough, and design and research can inform each other, that we will be able to, as Lagemann suggests, create "usable knowledge" (Lagemann, 2002), that is, knowledge that helps us not only as scientists, but as educationists. ☐

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Acknowledgments: I gratefully acknowledge the advice and help of Ali Carr-Chellman and Josh Kirby in thinking about the connections and disconnections between ISD and LS; the contributions of the Design-Based Research Collective *(http://www.designbasedresearch.org/)* to my thoughts on research and design; and Jason Ravitz for originally helping orient and introduce me to the Instructional Systems Design community. I also acknowledge the financial support of the Spencer Foundation and the Learning and Performance Systems Department at Penn State University.