

An Overview of Progress and Problems in Educational Technology (1)

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Abstract

Educational technologists have promised that great advances and improvements in learning and instruction would occur on account of new and emerging technologies. Some of these promises have been partially fulfilled, but many have not. The last decade of the previous century witnessed the consolidation of new approaches to learning and instruction under the banner of constructivism. This so-called new learning paradigm was really not all that new, but renewed emphasis on learners and learning effectiveness can clearly be counted as gains resulting from this constructivist consolidation within educational research. At the same time, technology was not standing still. Network technologies were increasing bandwidth, software engineering was embracing object orientation, and wireless technologies were extending accessibility. It is clear that we can now do things to improve education that were not possible twenty years ago. However, the potential gains in learning and instruction have yet to be realized on a significant global scale. Why not? Critical challenges confront instructional designers and critical problems remain with regard to learning in and about complex domains. Moreover, organizational issues required to translate advances in learning theory and educational technology into meaningful practice have yet to be addressed. The current situation in the field of educational technology is one of *technification*. New educational technologies are usable only by a scarce cadre of technocrats. Constructivist approaches to learning have been oversimplified to such a degree that learning effectiveness has lost meaning. As a consequence, education is generally managed in an ad hoc manner that marginalizes the potential gains offered by new learning technologies. This paper presents an overview of progress and problems in educational technology and argues that educational program management must be integrally linked with technology and theory in order for significant progress in learning and instruction to occur on a global scale.

Introductory Remarks

Educational technology is rich with speculation about dramatic improvements in learning and instruction that will be realized through innovative applications of new technologies. History tells a different story. Thanks to such technologies as interactive simulations, the Internet, streaming media, and virtual reality, educational technologists can do amazing things. Educators can represent a great variety of complex phenomena in school settings that would have previously required expensive field trips and only limited opportunities for interaction. Educators can apply voice recognition to foreign language training and use conversational interfaces so that learners can practice speaking skills in realistic settings. Educators can record and replay noteworthy events. Rich digital resources exist for nearly every topic of concern, and technology development continues at a mind-numbing pace.

In the 1980s it was predicted that intelligent tutoring systems would produce dramatically significant improvements in learning, similar to the two-sigma effects that Bloom (1984) had documented for some one-to-one human tutoring situations. Such improvements did not occur. What did materialize were somewhat less significant improvements in a few very well-defined learning situations and the realization

that it was extremely difficult to create a dynamic computer model of what a learner understood about a particular subject at any given moment in time.

In the 1990s it was predicted that distributed learning and tele-collaboration would make classroom teaching and teachers obsolete. This did not happen. What has materialized is the realization that collaboration at a distance is often quite difficult and challenging. We have also realized that the role of the teacher is not likely to be eliminated by technology. Rather, the role of teaching in technology-intensive settings is more difficult and more challenging than ever before. Only a rare few master the knowledge and skills required to effectively integrate technology into everyday learning and instruction.

Yet we continue to invest significant resources into educational technology. Why? Many people have an implicit faith that technology will generally make things better, including education. Such faith is ill-founded. It is true that technology has been a centerpiece in many instructional systems and learning environments. However, technology is not what learning is about. Learning is fundamentally about change. Most learning theorists acknowledge that learning is marked by changes in attitudes and abilities that tend to persist over time. Technology can certainly be used to promote learning. Technology can also impede learning.

Advances in Educational Technology

One can arbitrarily date the history of modern educational technology with the use of radio to deliver instruction in the early part of the 20th century. There were successful uses of radio-based instruction in Australia, Canada, the USA and elsewhere (Beagles-Roos & Gat, 1983). Using radio for teaching in most instances was driven by the remoteness of learners and the ease with which radio could reach those learners. As with subsequent technologies, when radio-based instruction was introduced, there was much enthusiasm about its potential to improve learning on a global basis (Tyack & Cuban, 1995). What occurred was somewhat less dramatic than what was promised.

Such promises of dramatic improvements in learning, coupled with the ability to reach learners neglected due to remoteness or resource constraints, were repeated with the advent of television and then again with regard to the introduction of personal computers (Tyack & Cuban, 1995). These promises of technology-transformed learning and instruction exist now in conjunction with networked learning environments and highly interactive multimedia that are widely accessible and affordable.

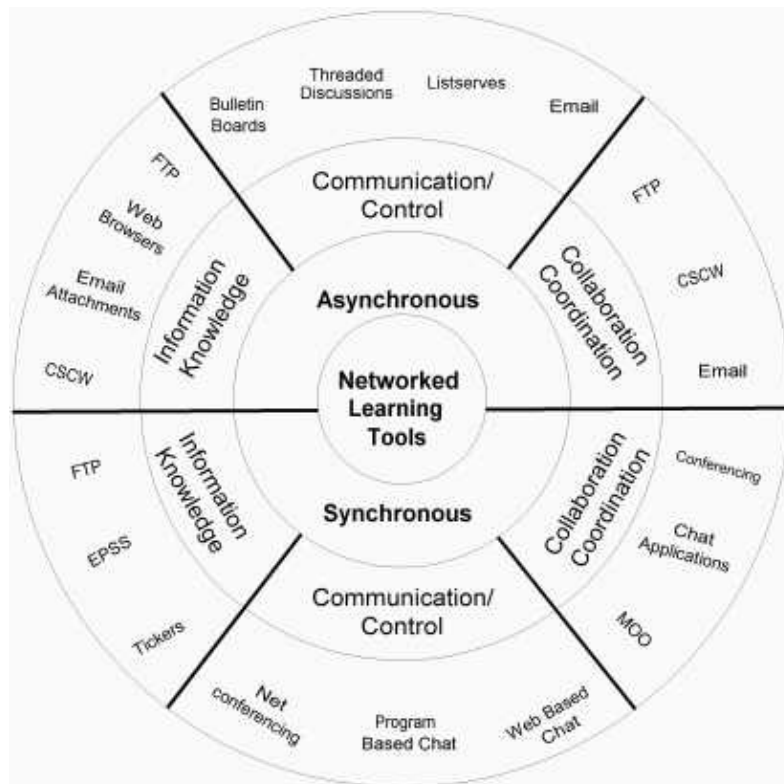


Figure 1. Networked learning tools (see Ganesan, Edmonds & Spector, in press).

Networks bring learning support and instructional materials to learners who can potentially access materials anywhere, anytime. Interactive multimedia provide a level of manipulation that can engage learners and activate exploratory learning. This is accomplished by using a number of tools ranging from simple email to computer-supported collaborative work (CSCW) environments (Wilson, 1991). It is possible to use networks to share web-based resources and deploy powerful electronic performance support systems (see Figure 1, developed by G. S. Edmonds in Ganesan, Edmonds, & Spector, in press). While developments in networked and collaborative settings have received a great deal of attention in the literature, there is not nearly as much research on the changing nature of instructional design due to such systems. Moreover, there is little consideration given to the demands placed on designers to make effective use of these technologies or of the ability of teachers to master the requisite knowledge and skill to effectively integrate such tools into their everyday teaching.

It is not rare or surprising that new tools and technologies introduce new challenges and problems. What is noteworthy is the pace of development in educational technology and the need for teachers and designers to keep up with that pace. The tools and technologies indicated in Figure 1 are not by any means exhaustive. The tools and technologies associated with interactive multimedia are similar in number and complexity. How can teachers and designers maintain their knowledge and skills with regard to educational technology? As teachers and designers fails to keep pace, educational technology becomes more and more a domain of special expertise. As a consequence, educational reform and progress fall into the hands of technocrats.

The term *technification* is introduced to indicate a domain largely controlled by and accessible to only those with special knowledge and skill. Before examining the technification of educational technology, I shall first review what has been called the new learning paradigm and indicate some specific challenges for instructional designers associated with these changes.

Reconstructing Learning

In the midst of the many promises and problems associated with using technology-based resources in teaching and learning, there are conceptual issues to confront. One such issue concerns the nature of

learning. Some suggest that a new learning paradigm is emerging on account of new technologies (see, for example, Koshmann, 1996; Spector & Anderson, 2000). While it is true that technology has been a centerpiece in many instructional systems and learning environments, technology is not what learning is all about. As noted earlier, learning is essentially about change. Learning involves changes in attitudes, beliefs, capabilities, knowledge structures, mental models, and/or skills. When these changes have been observed and are believed to be stable (likely to persist for some time), it is reasonable to say that learning has occurred. The definition of learning is not changing. Learning is still essentially about change. Rather, what is changing is how to facilitate and support effective learning, especially with regard to new technologies and complex subject matter.

It is fair to say that the conceptualization of learning activities (not learning itself) has undergone dramatic change in the last twenty years or so. Part of this conceptualization is renewed interest in how peers contribute to and support learning, especially with regard to subjects that are complex and challenging from the learner's perspective. Once interest is broadened from an individual learner to a group of learners (a learning community), the need to introduce new assessment methods arises. Action research and activity theory provide new perspectives and methods (see, for example, Koshmann, 1996). However, the use of action research and activity theory is not yet so rigorous nor so widespread as to provide a solid basis for an improved understanding of the conditions that facilitate learning in various circumstances. This situation is likely to improve with time.

A large part of the so-called new learning paradigm involves a shift from what has been called an atomistic perspective to a more holistic perspective (Spector & Anderson, 2000; Spector & Davidsen, 1999; Spector et al., in press). The atomistic perspective emphasizes individual units of learning (specific and discrete conditions, methods, and outcomes) and treats learners in an isolated manner (focusing assessment on individual learners and evaluation on aggregates of individual assessments). This atomistic perspective can be contrasted with what Spector (1994, 1995) called an integrated and holistic perspective. The holistic perspective views a person as a member of a society and as a member of various language communities and communities of practice. The overall goal of a language community typically involves a strong survival element, often not made explicit. In this perspective, living consists of working and learning, which are viewed as collaborative efforts toward commonly held goals. This social perspective and the realization that learning is often aimed at integrated collections of human activities (Gagné & Merrill, 1990) comprise a holistic perspective of learning. From the holistic perspective, learning is ultimately aimed at improving the understanding within a community of various phenomena and situations; learning is not merely about recalling specific facts or solving specific problems and learning assessments should reflect this.

There is much to celebrate in this constructivist consolidation of learning research, some of which has been made possible by technology. However, this new learning perspective does not eliminate the need for instructional design. Rather, this enriched view of learning makes the task of designing meaningful learning experiences more challenging than ever before. Moreover, the technologies that potentially enable the realization of learner-centered environments depend on expert knowledge of systems (computer systems, instructional computing systems, knowledge management systems, etc.) not typically found in teachers and rare enough among instructional designers. The next two sections examine such issues.

Challenges for Instructional Designers

Jonassen and colleagues (2000) argue that the new learning paradigm is predominantly and fundamentally constructivist, as just described. Resnick and colleagues (1991) argue that the new paradigm is fundamentally social, as in socially shared cognition. These views are generally compatible and are espoused by many other prominent educational researchers (see, for example, Bruner, 1985; Collins, 1991; Lave, 1988; Lave & Wenger, 1990; Pea, 1993; Spector & Anderson, 2000). The reality that these changes represent for the designer is not revolutionary since the fundamental definition of learning as involving changes remains intact. However, these changes do add to the complexity of design. For example, it is not simple to decide to what extent an open-ended, exploratory environment is likely to be effective with specific learners for a given subject, or to compare that alternative with a guided discovery approach.

Deciding how to effectively implement and support socially situated learning activities is likewise complex. Balancing costs and expected outcomes of alternative solutions is no simple matter, especially since newer approaches have little effectiveness data on which to build realistic expectations or construct realistic cost–benefit analyses.

Let us focus on just the communication, coordination and control aspects of new information technologies, since they might be regarded as especially prominent (Ganesan, Edmonds, & Spector, *in press*; Kling, 1991; Malone & Crowston, 1993). Information is basic to nearly everything that occurs in a technology–facilitated environment. Information is being passed along and processed in a variety of ways at different levels. As computer and network systems have advanced, it became obvious that databases (structured collections of information) were vital. Even more useful are knowledge management systems that provide rules for accessing, browsing, interpreting, interrelating, modifying, reusing, and extending the information in a database. Associated with each major technology generation are new and more complex tasks for instructional designers, as suggested in Figure 2.

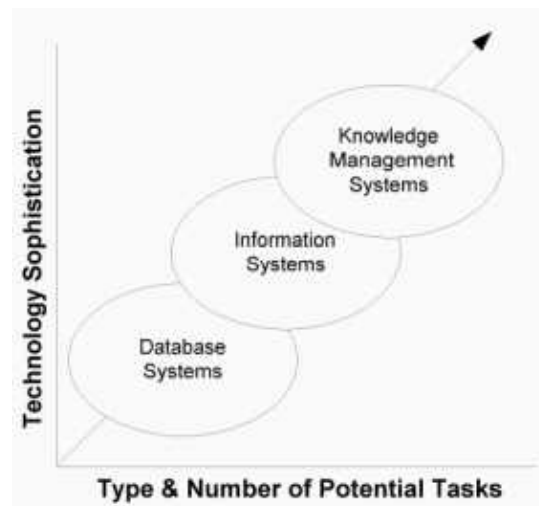


Figure 2. Networked system sophistication (see Ganesan, Edmonds & Spector, in press).

Information and the means to structure and manage that information is required in order to have an effective system (Spector & Anderson, 2000). When learning tasks are complex and socially situated, which is the case more and more often (Jonassen et al., 2000), support for collaboration and cooperation on a variety of learning activities is required. Most often, that support is related to the coordination and communication functions of the system. However, as tasks and activities are distributed, it becomes important to maintain some kind of control to insure that work is not unnecessarily duplicated or lost, that appropriate information is accessible and shared, and that project deficiencies are identified and repaired. Instructional design in such an environment is a complex and ill–structured process (Goel & Pirolli, 1989). Apart from the complexities introduced by technology, there are a diverse set of problems and considerations that comprise instructional design (Rowland, 1992). One aspect of instructional design complexity concerns the variety of tasks to be accomplished. An instructional designer may interact with managers, with people performing training tasks, with subject experts, with system specialists, and so on. A designer proposes solutions and defends project plans, manages a project, chooses media, develops storyboards and other products, conducts evaluations, and so on. It is rare to find one individual who can perform all of these different activities or who would have the time to perform them all on a large–scale effort or for several projects. As project complexity grows, so does the need to collaborate and to coordinate activities.

Another aspect of instructional design complexity concerns the ill–structured nature of goals and requirements. It is rare to find a client who has well–articulated goals and requirements for a learning environment or instructional system. It is much more common to encounter a goal such as "put these courses on the web." The designer who confronts ill–structured goals confronts a negotiation task that is dynamic. Goals and requirements are likely to evolve as the project proceeds. Managing activities in the face of changing requirements is a complex and challenging task. Effective management in this context requires effective communication, coordination and control processes.

Associated with this particular challenge is the negotiation of how best to achieve goals and requirements. There are almost always alternative ways to implement a learning environment. Costs are usually a primary concern, although contexts, learning outcomes and organizational impact are of obvious importance. Again it is difficult to imagine any one person mastering such different areas of expertise. It is especially rare to find a well-developed and documented cost-benefit analysis for a technology-based educational project. At the course or lesson design level, instructional designers confront the issue of distributing specific course events and activities in a variety of settings versus putting the entire course online. One of the big lessons learned over the years with regard to educational technology is that it is not likely to be effective or efficient to simply replace one delivery medium with another without consideration given to particular learning activities and situations. It is tempting to think that one can replace a less experienced teacher with a video tape, or that one entirely replace classroom instruction with a computer-based tutor. The real complexity for designers arises when they try to match subject matter with learner characteristics and appropriate instructional methods. New technologies offer designers many options for combining instructional contexts. The instructor-led model is giving way to hybrid course designs that include a combination of technology-mediated events and traditional classroom events. Distributed forms of interaction, including virtual communities and tele-mentoring, are feasible. These types of interactions allow for a community of learners to exchange information, communicate about ideas and problems, and collaborate in developing experimental artifacts outside the classroom. Learning can be embedded in the workplace. Distributed learning can encompass a wide array of scenarios, which can potentially involve the use of many different technologies and learning contexts. This certainly adds significantly to the complexity of design.

Collaborative software that allows users to easily communicate, coordinate, and collaborate are recent innovations. Previous developments lead to the development of new forms of CSCW (Ganesan, Edmonds, & Spector, in press). Internet tools (e.g., email and electronic bulletin boards) are useful for communicating among team members but using these tools to distribute and collaborate on documents is burdensome. Using these tools to edit documents can be confusing and time-consuming. For example, if the owner of a document emails it to 10 team members, then 11 versions of the document now exist all with the potential to contain edits, and rewrites. If a document is sent to users in a linear manner, as with paper documents, one user can stop the entire process. The creation of web pages to share information can also be cumbersome, forcing teachers and designers to create platform documents and requiring users to install additional software. Tools such as Xerox DocuShare and SevenMountains 7M Integrate allow users to employ the software applications that they already use (Ganesan, Edmonds, & Spector, in press). In addition, these provide version control and automatic tracking of updates, and that removes the burden of document control and coordination from a project manager. Such powerful CSCW software allows for geographically separated team members to contribute to a project, so collaborative instructional design can become a reality (Bannon, 1991; Bannon & Schmidt, 1989; Hughes et al., 1991).

Whenever newer information and communications technologies have emerged, the trend has been for those technologies to find their way learning and instruction. When the Internet exploded, the educational focus became providing distance learning using the Web. Not much thought was given to the design aspects of the instructional materials or to the entire learning environment itself. One can use new technologies to support instructional design and recent work in the area of web-based learning reflect a much more mature use of the web to support learning and instruction. Experience with tools like Xerox's DocuShare and SevenMountains 7M demonstrate that we can also use CSCW tools to support the collaborative design of instruction (Ganesan, Edmonds, & Spector, in press). Such tools provide the new dimension of distributed support for collaborative instructional design. This is likely to have an impact on how instructional designers work. Organizations effects and effects within higher education of such new technologies remain somewhat unclear and not clearly associated with causes (Hanna 1989; Heller, 2001).

Technification

The problems that can occur when introducing technology into teaching and learning are significant (Feldman et al., 2000). There are problems concerning the preparation of teachers and learners. These are

more or less well documented, although the pitfalls due to lack of teacher training and student preparation are often overlooked in the haste associated with acquiring and implementing new technologies. Institutional pressures are many and complex. Different interest groups lobby for particular technologies. Restrictive institutional practices and short-sighted policy planning can result in wasteful investments and in the alienation of constituencies (Rosenberg, 2001). More important, perhaps, is the degree to which educational technology has become the domain of those with special knowledge and skills. The term selected to reflect the degree to which technocrats dominant a field in this paper is technification. If one compares current technologies with those of the first half of the last century (i.e., radio and television), one can say that while producing radio and television broadcasts requires special expertise, this was accomplished with close coordination and involvement of teachers and instructional designers. It is now more common to find teachers reporting that they feel alienated from educational technology and there are many reports of a paucity of well-trained educational technologists. The outcome of this situation is that it often happens that educational decisions are made by those with technology expertise, leaving many teachers and designers and parents outside decision-making channels. Moreover, the social and global implications of the digital divide (of which technification is but one symptom) are much discussed but not especially well understood. Many who are conducting research in the area of technology-based learning are very optimistic about the potential to confront the digital divide. However, many countries still lack basic infrastructure to even advance to a stage where technification becomes a problem. It appears that the divide is widening in the area of e-commerce. Investments of the European Commission, the United Nations, the World Bank, and many national research foundations in spreading e-learning to developing countries may eventually help in this regard. However, when required infrastructure is lacking, such efforts only serve to highlight the digital divide. One change due to networks and interactive multimedia involves the blurring of the distinction between learning and working. Individuals may shift thoughtlessly from performing a work activity into a learning mode through a system-initiated help environment. Workers may put one task on hold while taking time out for a tutorial. Individuals may unwittingly activate background agents to gather information on selected topics which are then pushed into windows that appear in the user's desktop work environment. Workers may shift from working alone on an isolated task to seeking guidance and advice from a community involved in similar activities. Such technology-enabled opportunities generally require an appropriately trained cadre of teachers and designers or else they become the province of the technology-informed and technification sets in. Ironically, new technologies are touted as democratizing education, especially the Internet. The reality of technification is that technology-based education may become far less democratic than traditional classroom-based education. In short, changes more revolutionary than constructivism are underway. These changes most definitely make instructional design more challenging than ever before. These changes can be found in the workplace with adult learners. They can also be found in schools with learners of all ages. Organizational changes are afoot, in part in association with the phenomenon of technification just described. One set of changes involves attitudes with regard to workplace learning. This concern is partly a result of the growing support for lifelong learning and it is partly a result of emphasis on developing a genuine learning organization (Dean & Ripley, 1998; Senge, 1990; Wagner, 2000). The complexity that these changes produce for designers and teachers include the requirement to take a much larger and longer perspective on learning and instruction than the traditional focused perspective of designing and teaching a course. An example of such a longer-term perspective is the notion of designing for re-use. This notion is now the province of educational specialists who are familiar with knowledge and learning objects and associated metadata tagging mechanism. The interested reader can explore the extensive literature on SCORM – Shareable Courseware Object Reference Model Initiative – and ADL – the Advanced Distributed Learning Initiative – efforts initiated by the US Department of Defense and Office of Science and Technology Policy. The advantage of knowledge tagging and instructional metadata is that they allow material stored in digital repositories to be found and reconfigured for specific learning needs. Such use was demonstrated about 15 years ago with the hope that this technology would further democratize technical training (Spector, Arnold & Wilson, 1996). However, there is now 15 years of evidence that metadata tagging and reusable knowledge objects remain the purview of technocrats. Indeed, within the domain of software engineering it was argued that object-oriented programming would eventually make it possible for domain specialists to describe systems so that computer code to support

specific requirements could be automatically generated, at least in part. This was seen as a way of extending the programming language further from machine level toward the level of describing problems in everyday language. Object orientation was supposed to revolutionize programming and make it in principle for most technical specialists to be programmers. This has not happened. Quite the contrary, reusable software objects are not generally accessible outside small communities of specialists. It is not surprise that a similar development has occurred with regard to knowledge objects. This is but another example of technification. It may not be avoidable and it is not necessarily undesirable, so long as progress does occur to extend the potential gains to larger communities of users.

Finally, some of these new learning opportunities are embedded in or associated with information systems already in place in work settings. A designer cannot simply produce a learning solution apart from some consideration of such systems. Indeed, the requirement may be to embed the training within an information or knowledge management system, as we shall soon see. Again, such a situation increases the complexity of instructional design decision-making and makes it more likely that those with special expertise will remain critical in designing, implementing and managing large, technology-based learning environments.

Concluding Remarks

How far has educational technology come? Consider Robert Gagné's views on educational technology (see, for example, *The Legacy of Robert M. Gagné* edited by Rita C. Ritchey, available through ERIC-IT – <http://ericir.syr.edu/ithome/TOCs/gagne.html>). For Gagné, the learning goal (especially the kind of knowledge or skill to be learned) determines to a great extent how to design effective support for learning (i.e., instruction). What has happened along with advances in technology is that many educational researchers explicitly or implicitly discredit this and other fundamental principles of instructional science. The result is that while many dramatic educational technology applications are being created there is very little empirical research being conducted with regard to their effects on learning. As a consequence, we have little evidence on which to base a judgment with regard to the advantages of using specific kinds of technology in various educational settings. We continue to invest in technology and proceed on the basis of our implicit faith in technology-enhanced learning and instruction.

Vast resources have been invested in technology-enhanced learning and instruction. Many people have faith that technology will make education better. Such faith is ill-founded. One lesson from the previous century with regard to the effective integration of technology into teaching and learning is that instructional planning is more complicated than ever before (Spector & Anderson, 2000). The big lesson about technology and learning from the 20th century is that less is known about how people learn than many educational researchers are inclined to admit. The big lessons that we should have learned about educational technology in the last 50 years include the following:

- Technology intensive education is not necessarily inexpensive and the benefits are not always clear; it typically requires significant initial investments in resources and training; long-term learning outcomes and generalizable results are seldom studied with the rigor associated with more established solutions; if we apply the WYMIWYG principle (what you measure is what you get), then we really do not know what we are getting.
- Wholesale replacements of one form of delivery with another have seldom proven effective across a variety of settings; hybrid or mixed-delivery solutions can offer a path for graceful growth and development while retaining the best features of proven solutions.
- Many learning objectives are unstated or not explicitly formulated; ignoring these is not likely to lead to systemic improvement in learning and instruction.
- Some legitimate learning goals are effectively met with traditional and well-established methods; we need not abandon what we know works well when embracing new technologies.

Some technology advocates so far as to claim that schools should be abandoned or radically reformed (see, for example, *Engines for Education* at http://www.ils.nwu.edu/~e_for_e/nodes/NODE-283-pg.html for an elaboration of this perspective). Perhaps the most disturbing trend in educational technology appears to be

an abandonment of a scientific attitude with regard to learning and instruction. Some even regard learning theories as harmful; see Brent Wilson's article "The Dangers of Theory Based Design" (<http://ifets.ieee.org/discussions/discuss7.html> in the ITFORUM archives). For an argument in favor of retaining a scientific attitude see Dave Merrill's paper entitled "Learning Strategies Then and Now: Same of Different?" (posted at (<http://ifets.ieee.org/discussions/discuss7.html> on the International Forum of Educational Technology and Society web site).

In spite of justifiable skepticism with regard to educational technology, it seems quite likely that innovative applications will continue to emerge and that educational technology will be used more pervasively and in an increasing variety of ways. Are there specific concerns about this irresistible trend towards technology-centered education that deserve attention? I believe that there are. Peter Goodyear argues that we should take life-long learning seriously and, therefore, re-examine learning as a kind of work, in stark contrast with those who advocate using technology to make learning more like entertainment (see his paper in the *Journal of Courseware Engineering* at <http://www.ifi.uib.no/icce/JCE/JCE-02-goodyear.pdf>). Yvonne Wærn addresses the need to re-examine the concept of performance improvement in light of distance learning possibilities (see her paper in the *Journal of Courseware Engineering* at <http://www.ifi.uib.no/icce/JCE/JCE-02-waern.pdf>). Goodyear and Wærn both address what is now being called the ecology of learning and learning spaces. Alexander Voiskounsky addresses cultural issues in "Internet Diversity of Unification?" (<http://www.ifi.uib.no/staff/konrad/research/culture/DalexApplicatICA98icapaper.htm>). Voiskounsky argues that a kind of cultural shock is arising in subtle ways on account of the pervasiveness of the Internet, but he is optimistic that we can effectively respond to these cultural issues through planning and implementations that make cultural aspects explicit throughout the process.

The design and planning of instructional systems and learning environments have not become simpler on account of advances in technology; nor has teaching become simpler. Rather, these activities have become significantly more difficult. The fact that it is more challenging than ever to properly design and implement technology-intensive learning solutions has not been fully appreciated by very many organizations, although it is well understood by some academics (e.g., see the International Board of Standards for Training, Performance and Instruction – *ibstpi* – recent update of the Instructional Design Standards at <http://www.ibstpi.org/98comp.html>).

The greatest potential for educational technology to improve education perhaps exists in support of understanding complex problems and domains (Spector & Anderson, 2000). We know reasonably well how to support learning simple concepts and procedures, and we know how to make effective use of technology to support such learning. The educational research community is now addressing how to effectively promote understanding of ill-structured problems that occur quite naturally in many complex settings (e.g., how to maintain sustainable levels of resources in a region with an increasing rate of development and population growth). A genuine sign of the maturity of educational technology is that serious research is now occurring in areas where there is relatively little known about improving learning and understanding (Spector & Anderson, 2000).

While one ought to be skeptical about dramatic improvements in learning due to new technologies, one cannot ignore what is happening in education due to the advent of the Internet. Networked learning certainly has the potential to improve learning on a global basis and will surely influence the future in many ways. However, there appears to be little systemic understanding of how these changes will evolve. I shall close with five principles that I regard as fundamental for effective use of technology and for improvements in learning and instruction:

1. Learning is fundamentally about change – the Learning Principle.
2. Experience is the starting point for understanding – the Experience Principle.
3. Context determines meaning – the Context Principle.
4. Relevant learning contexts are often broad and multi-faceted – the Integration Principle.
5. We know less than we are inclined to believe – the Uncertainty Principle.

If we wish to come further than we have in advancing education, then such principles should guide research and development. The Uncertainty Principle is perhaps the most fundamental of all and serves as a reasonable point of departure for educational research. Educational technology will have arrived when it

can be demonstrated with confidence that certain kinds of improved learning outcomes are the result of specific technology-enabled changes that have been integrated successfully in schools and work settings on a widespread basis. The road ahead is long but promising.

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<http://askeric.org/ithome/docs/volume21issue2/features.shtml>. Portions from "The Changing Nature of Instructional Design for Networked Learning" by Ganesan, Edmonds, Spector have been used as a basis for this expansion.