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**Tools of Termlessness:  
Technology, Educational Reform, and  
Deweyan Inquiry**

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Timothy Koschmann  
Department of Medical Education  
Southern Illinois University  
P.O. Box 19230, M.S. 1217  
Springfield, IL 62711-9230  
e-mail: [tkoschmann@acm.org](mailto:tkoschmann@acm.org)  
voice: (217) 785-4396  
fax: (217) 524-0192

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The use of a term that designates a potentiality rather than an actuality involves recognition that all special conclusions of special inquiries are parts of an enterprise that is continually renewed, or is a going concern.

John Dewey (LW12:16–17)<sup>1</sup>

There has been a long-standing debate concerning the potential of instructional technology to achieve dramatic and revolutionary improvements in the practices of education (Cohen, 1988; Cuban, 1986; Papert, 1997). On the one side are the proponents of more extensive use of computer and telecommunication technology in education (e.g., Morrison & Goldberg, 1996; Nelson, 1970, 1974; Papert, 1980, 1993). Papert (1993), a particularly eloquent spokesman for this position, has argued that technology, under such circumstances, might lead to a "magachange" in instructional practices. On the other side, Cuban (1992) has described how new technologies are often used in ways that simply reinforce the prevailing cultural beliefs about education, namely that "[t]eaching is telling, learning is listening, and knowledge is what is in books" (p. 27). Often side-stepped in this debate, however, is the more fundamental question, if we had the power to change instructional practice through the introduction of new technologies, what sorts of changes would we really like to see?

The chapters in this volume are all concerned in various ways with how we might go about constructing virtual environments to support learning. I think we have an obligation, however, as developers and promoters of such environments, to make explicit the theories of learning and instruction that motivate our work and that are embedded within our designs. Unfortunately, this is an obligation with respect to which we have, as a group, been largely derelict in the past.<sup>2</sup>

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<sup>1</sup>Standard references in this chapter to John Dewey's work are to the critical edition, The Collected Works of John Dewey, edited by Jo Ann Boydston (1969-1991), and published as The Early Works (EW), The Middle Works (MW) and The Later Works (LW). These designations are followed by volume and page numbers.

<sup>2</sup>This is not true, of course, for all designers of instructional technologies. Some designers have indeed endeavored to make the theories underlying their work explicit (e.g., Crook, 1994; Papert, 1980, 1993; Pea, 1996; Scardamalia & Bereiter, 1996). In general, however, they have been the exception to the rule. I think it is fair to say that most work in this area tends to be, in its design, technology- rather than theory-driven.

With this obligation in mind, I present in this chapter one particular theoretical approach to designing technologies that might be used to foster reform in instructional practice. I begin by exploring some ideas drawn from the writings of the educational philosopher, John Dewey. I then propose a new conceptualization for effective learning and instruction, designated Termlessness, that is linked to Deweyan notions of uncertainty, inquiry, and educational practice. I elaborate on the role that technology might play in fostering termless forms of learning and instruction. Following this, I show how the general notion of Termlessness is related to other current themes and initiatives for reforming educational practice based on recent research in learning and cognition. Finally, I conclude by discussing some of the implications of Termlessness for future work in instructional technology.

### **Dewey on Certainty, Inquiry, and Educational Practice**

Dewey, unfortunately, had little to say on the topic of how technology might best be used to support educational reform. He did write extensively, however, on the nature of knowledge, how people come to "acquire" it, and what teachers can do to foster this process. I will turn, therefore, to his writing on these topics (largely in his later works) for guidance in how we might design new tools to support more effective learning.

Dewey wrote at length about what constitutes valid knowledge. He held a pragmatic view that was ever informed by "observation and experiment" and by which "ideas are only tentative or working hypotheses until they are modified, rejected, or confirmed by the consequences produced by acting on them" (LW8:11). He distinguished this view from that of the "natural man" who is "impatient with doubt and suspense" and who "hurries to be shut of it" (LW4:182). He wrote:

Tendency to premature judgment, jumping at conclusions, excessive love of simplicity, making over of evidence to suit desire, taking the familiar for the clear, etc., all spring from confusing the feeling of certitude with a certified situation. . . . The natural man dislikes the dis-ease which accompanies the doubtful and is ready to take almost any means to end it. Uncertainty is got rid of by fair means or foul. . . . Love for security, translated into a desire not to be disturbed and unsettled, leads to dogmatism, to acceptance of beliefs upon authority, to intolerance and fanaticism on one side and to irresponsible dependence and sloth on the other. (LW4:181–182)

Dewey considered all forms of absolutism to be pathological and dangerous. He advocated instead a form of "fallibilism" (LW12:46). Consistent with this position is

his description of a "reflective" form of thinking as, "[a]ctive, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends" (LW8:118).

Dewey described the process by which he believed learners come to acquire knowledge of the world. Though he applied several names to this process (e.g., "phases of reflective activity" [LW8:199-209], "experimental method of science" [LW13:58]), it is, perhaps, best known by the title "inquiry" (MW10:320-365; LW12). Inquiry for Dewey was a response on the part of an organism to a state of "disequilibrium" (EW5:96-109) or "breakdown" (Koschmann, Kuutti, & Hickman, in press) within its ongoing, purposive activity. He defined inquiry as the "controlled or directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole" (LW12:108, author's italics). He stated further, "[t]hinking is objectively discoverable as that mode of serial responsive behavior to a problematic situation in which transition to the relatively settled and clear is effected" (LW4:181). He stipulated, however, that inquiry does not lead to a conclusion and then stop. Instead, it is a continuous and ongoing concern. He wrote:

Attainment of the relatively secure and settled takes place . . . only with respect to specified problematic situations; quest for certainty that is universal, applying to everything, is a compensatory perversion. One question is disposed of; another offers itself and thought is kept alive. (LW4:182, author's italics)

Given the importance of inquiry to knowledge, learning, and thought, it quite naturally assumed a central role in Dewey's recommendations on effective teaching (c.f., The School and Society [MW1], How We Think [LW8]). For Dewey, the ultimate goal of instruction is to encourage students to adopt an attitude that accepts and even embraces the condition of uncertainty and doubt. Dewey (LW4) wrote, "The scientific attitude may almost be defined as that which is capable of enjoying the doubtful; scientific method is, in one respect, a technique for making a productive use of doubt by converting it into operations of definite inquiry" (LW4:182).

### **Termlessness, Termless Learning, and Termless Instruction**

Mindful of the obligation that all designers of instructional technologies share to make explicit the theories of learning and instruction that motivate their work, my colleagues and I have endeavored in the past to articulate the theoretical

underpinnings of our own work. Toward this end, we proposed six principles of effective learning and instruction in domains that are ill-structured and complex (Koschmann, Myers, Feltovich, & Barrows, 1994; revised in Koschmann et al., 1996a). Of the six principles, one, known as the Principle of Termlessness, will be the focus of the discussion that follows.

The Principle of Termlessness was described as follows (Koschmann et al., 1994; Koschmann et al., 1996a):

Learning of rich material is termless; instruction should instill a sense of tentativeness with regard to knowing, a realization that understanding of complex material is never "completed," only enriched, and a life-long commitment to advancing one's knowledge. (p. 89)

Termlessness, like other words in everyday parlance such as termination, terminal, and terminus, is derived from the Middle English stem terme meaning boundary or end. Term-lessness, therefore, denotes the absence of boundaries or the quality of being without end. Applied to education, Termlessness signifies an attitude toward learning and knowing that regards knowledge, not as something that is acquired, but rather as a perpetual work-in-progress.

Why burden the language with a new word when there are already so many expressions with closely related meanings (e.g., lifelong learning, open learning, learning without frontiers, learning-on-demand)? As Newman, Griffin, and Cole (1989) observed, a new word "is a way to signal that old phenomena are being reconceptualized with a different kind of theory" (p. 59). The neologism Termlessness, therefore, introduces an epistemological component that is not necessarily developed in these earlier formulations. It goes beyond a simple commitment to the endless pursuit of knowledge to include a particular and provisional orientation toward what is known that motivates and sustains this pursuit. Just as Dewey was known for his "constant insistence that nouns such as 'mind' and 'knowledge' be treated as gerunds rather than substantives" (Hickman, 1990, p. 10), Termlessness treats understanding as contingent and continuously subject to revision. It represents a position, therefore, that is perfectly in keeping with Dewey's fallibilism and views on certainty.

Termless learning is simply learning that reflects an orientation of Termlessness. In education, we use the word term to denote a fixed period of study. Termless learning, on the other hand, is learning that is neither temporally bounded nor is it constrained by the arbitrary compartmentalization imposed by our

educational traditions of courses, subjects, and disciplines.<sup>3</sup> Termless learning is closely connected to Dewey's notion of inquiry. Such learning is not limited to situations of formal instruction, but rather occurs in all settings and in all phases of life. It is an ubiquitous and unending enterprise driven by a need to resolve a situation that is problematic or unclear. But, just as Deweyan inquiry does not come to a conclusion when a problematic situation is resolved, termless learning leads only to the need for additional learning.

Termless instruction is instruction designed to cultivate termless learning. This can be done in several ways. First, as Dewey made clear (LW8), instruction must place learners in situations that are indeterminate and doubt-provoking in order to stimulate the process of inquiry. Second, learners may need assistance in recognizing the problematic aspects of the situation and in developing a concrete plan for resolving them. Teachers must, therefore, provide "scaffolding" (Wood, Bruner, & Ross, 1976) to support learners in the inquiry process. Finally, (and, perhaps, most importantly) termless instruction must foster a tolerance for and appreciation of uncertainty. As Dewey wrote, "[a] disciplined mind takes delight in the problematic, and cherishes it until a way out is found that approves itself on examination" (LW4:182).

To summarize and make concrete, I offer the following six objectives for instruction designed to foster Termlessness and sustain termless learning. In many cases these objectives are closely linked to other ideas in the literature of educational research. The six objectives include:

- To teach generative skills of learning and inquiry rather than a basic inventory of facts. In this regard, termless instruction has strong connections to Papert's (1980; 1993) call for the introduction of a discipline of "mathetics" and the growing literature on what is sometimes referred to as "self-regulated learning" (Winne, 1995).
- To empower learners to determine both the scope and depth of their learning. Consider the contrast between an undergraduate survey course and a graduate seminar. The depth of coverage in a survey course is usually made very explicit (i.e., "Don't worry about that; you don't need to know it for this course"); its scope is comprehensive, but lacking in detail. In graduate seminars, on the other hand, the scope and depth of understanding are often open-ended, requiring the student

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<sup>3</sup>As Nelson (1970) put it, "There are no 'subjects.' The division of the universe into 'subjects' for teaching is a matter of tradition and administrative convenience" (p. 18).

to determine when to curtail inquiry. I provide this example only to highlight the importance of allowing learners to exert more control over the scope and depth of their own learning. It is not necessarily meant to argue that instruction at other levels could (or even should) be structured to emulate all aspects of the graduate school seminar.

- To ensure that all learning is motivated by a legitimate need to know (i.e., is need-driven rather than curriculum-driven). Ensuring that learning is motivated by a legitimate need to know is consistent with one of the dictums of research based on theories of activity, namely that all activity is "object-directed" (c.f., Leont'ev, 1978; Nardi, 1996). In keeping with this dictum, it is important, when designing instructional activities, to focus on the actual goal(s) of the activity for the learner. Linking learning to the immediate needs of the learner is also consistent with notions of "intentional learning" as developed by Scardamalia and Bereiter (1989). Finally, this objective overlaps in certain ways with what we have described in earlier work as the Principles of Activeness and Authenticity (Koschmann et al., 1994; Koschmann et al., 1996a).<sup>4</sup> As will be discussed later in this chapter, Termlessness is closely related to Activeness and Authenticity, not only as a theory about learning but also as a motivating force in the reform of instruction.
- To expose learners to multiple views and representations of an issue and encourage them to apply multiple strategies in approaching problems. This objective is really just a reiteration of the prescriptive component of what we have in other contexts referred to as the Principle of Multiplicity (Koschmann et al., 1994; Koschmann et al., 1996a). It is highly relevant to termless instruction, however, especially with respect to discouraging 'one-stop shopping' for sources of knowledge in favor of the use of a rich diversity of electronic, print, and human resources.
- To encourage, at the same time, reflection on the credibility and authority of all sources of knowledge, both new and previously held. This can also be seen by

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<sup>4</sup>These two principles were stated as follows:

Principle of Activeness: Learning is an active process, requiring mental construction on the part of the learner; instruction should foster cognitive initiative and effort after meaning. (Koschmann et al., 1996a, p. 88)

Principle of Authenticity: Learning is sensitive to perspective, goals, and context, that is, the learner's orientation, goals, and experiences in the learning process determine the nature and usability of what is learned; instruction, therefore, should provide for engagement in the types of activities that are required and valued in the real world. (Koschmann et al., 1996a, p. 91)

comparing a lower-level survey course with a graduate seminar. In the survey course, the warrants for a fact are seldom specified and controversial aspects of the field are often glossed over. In the graduate seminar, on the other hand, students are called upon not only to recount the basis for accepted fact, but also to critique that basis. Graduate students are also (often for the first time) exposed to the provisional nature of scientific fact. This objective, in its focus on credibility and authority, dovetails with Bruffee's (1993) discussion of "nonfoundational" models of knowledge.

- And, finally, to instill the recognition that the understanding of complex material is never completed, but is instead termless. This, of course, is at the core of what is meant by termless learning and follows directly from the definition of Termlessness.

### Tools of Termlessness

With this target in mind of the type of instruction that we would like to see pursued, we can now turn to the question of how technology might be used to support it. Because the technologies that I am about to describe are connected in such a fundamental way to the notion of Termlessness, I refer to them as tools of termlessness. These tools can be divided into two categories of use, that is tools for access and tools for publication. As we will see, however, the division is somewhat arbitrary since the two categories are closely inter-related. I will describe each in turn.

Tools for access. Newman's (1993) distinction between instructional methods that "deliver" information as opposed to methods that stress informational "access" is an important one when considering how technology might support Termlessness. Early visionaries, such as Illich (1971) and Nelson (1974), foresaw a time in which technology would radically alter the ways in which people learn and information is accessed. In some ways, this vision has begun to be realized through the emergence of resources such as CD-ROMs, digital libraries, electronic bibliographic retrieval, and the World Wide Web (WWW). Making more information readily accessible to learners is obviously a good way of fostering termless learning. There is much to be done, however, before termless learners will be able to seamlessly access the knowledge of the ages. Providing gracious access to what is known stands as one of the "grand challenges" for research in information technology, one which will call for major advances in human-computer interface

design and in the cataloging and organization of knowledge (traditionally the purview of the Library and Information Sciences).

For a better appreciation of the problem, consider the difficulties in currently accessing information on the WWW. Topic-based searches, such as those offered by services like Yahoo™, are often hit-or-miss. The established categories may not provide a good fit with the requirements of a particular search. On the other hand, full-text searches, such as those offered by Alta Vista™, often produce unmanageably large numbers of "hits" (Soloway & Wallace, 1997). What is the value of a search, if the solution set contains twenty-thousand entries? This situation can only be expected to get worse as the amount of information accessible through the Web grows exponentially.

A related problem can be seen when we look at the current practices of professionals seeking information in the primary literature. Commercial services provide access to databases of bibliographic entries. Users can retrieve references by title, keyword, author name, or, in some cases, by the literature cited in the piece (e.g., Social Science Citation Index™). However, available databases only contain the references (and, in some cases, abstracts), not the texts of the articles themselves. This situation is rapidly changing, however, with many journals beginning to publish electronically. Indeed, it can be predicted that in the not too distant future the full text of all articles will be available online. The question becomes, however, what tools will we use to search such a vast corpus of information?

I see a number of promising initiatives that may begin to address these problems of information access. Some of the encyclopedia publishers are beginning to embed "hot" links into the electronic versions of their products. Because of their extensive experience cataloging information, these publishers are well-positioned to provide resources containing both well-researched background articles along with pointers to newer and changing information. New kinds of software tools might also be developed to simplify information search. Search engines, for example, might begin to offer intelligent "critiquing" (Fischer, Lemke, Mastaglio, & Morch, 1991) of user search strategies, making it easier for users to effectively find what they are looking for. Ongoing research on autonomous information-seeking agents, sometimes referred to as "knowbots" (Maes, 1994), may also lead to powerful new tools for information access.

Tools for publication. There is a venerable tradition in education of assigning term papers as part of the requirements for completing a course. On the surface there appears to be some value to this practice. In writing a term paper, students are

called upon to inquire deeply into a particular subject, they must organize their thoughts into a coherent form, and they must formulate (and argue for) a particular view or position. Although these components might seem to be consistent with the objectives of termless instruction, in practice they often fall short of this ideal. In order to understand what kinds of tools might be needed to support publication, therefore, we might start by evaluating this common instructional activity in the light of the previously articulated goals of termless instruction. This will serve as a segue into a discussion of the ways that technology might support a transition from the production of term papers to the production of, what might be called, term-less papers.

In listing the objectives of termless instruction, it was suggested that students should be empowered to determine the scope and depth of their learning. Superficially, term papers would appear to support this goal. However, in many settings in which term papers are assigned, students are assigned the same topics every semester. Since students are discouraged (in most cases, forbidden) to build upon the work of students from earlier semesters, this system guarantees that the same ground will be tediously explored every term. Modifying the system in such a way that the research performed by students in a given semester is made available as a resource to other students in the future would encourage students in each semester to increase the breadth and scope of their inquiry. As argued by Scardamalia and Bereiter (1996), this would also have the effect of converting the culture of the school into that of a "knowledge-building community," not unlike that found in communities of scholarly researchers.

A second objective of termless instruction is to ensure that all learning is need-driven rather than curriculum-driven. In many courses, the topics for term papers are determined by the instructor without regard for student interest. In so doing, students are deprived of opportunities to define for themselves what constitutes an appropriate and researchable topic. Since posing and refining a topic are skills that we would like students acquire, depriving them of opportunities to perform these tasks in school runs counter to the philosophy of termless instruction. When a student's sole interest in completing a paper is merely to satisfy the requirements of a course, it is not surprising that only a minimal effort is exerted toward completing the project. A termless paper, on the other hand, is always written first and foremost to serve the needs of the author, that is to serve as a vehicle for developing the author's thought.

A third objective of termless instruction is to expose students to multiple views and representations of an issue. Conventional term papers often fall far short of this ideal, however. Students are called upon to research and compose their papers in isolation. The completed paper is usually only read by one person, the teacher, and, in many cases, this is done only in a cursory fashion. A termless paper, on the other hand, is meant to be a "dialogic" (Bahktin, 1981) object involving an interaction among multiple voices. Termless papers, therefore, need to be written with a real audience in mind and must be developed in an environment that encourages revision in the light of interaction with this audience. As the name would imply, termless papers, like termless learning, are never completed.

Technology can support the development of termless papers in several ways. The means by which technology might be used to facilitate information access have already been discussed and, clearly, improving access to information would greatly contribute to the development of termless papers. Writing of termless papers requires more than this, however. We need new and better tools for organizing and composing ideas and these tools need to be better integrated with available tools for accessing information.

Current WWW browsers represent the wrong model for tools designed to support the production of termless papers. The dictionary defines browsing as, "inspect[ing] something in a leisurely and casual way."<sup>5</sup> The sort of disinterested meandering that this definition conjures up is just the opposite of the type of absorbed and object-directed research engendered by termless learning. One might browse the daily paper, for example, but exploring a more dense and difficult kind of work usually calls for a different type of reading. Such a reading requires posing questions to oneself, establishing connections to other ideas one has encountered in the past, and inserting comments and annotations into the text. Current browser designs are completely inadequate to support this latter type of research. What is needed, therefore, is a new type of tool for gathering, manipulating, and annotating information resources.<sup>6</sup>

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<sup>5</sup>The American Heritage Dictionary of the English Language (3rd Ed.), Boston, MA: Houghton Mifflin.

<sup>6</sup>An instructive example of just what such a tool might look like would be the old Notecards system (Xerox Special Information Systems, 1986; Halasz, 1988), originally developed at Xerox as a data-sifting tool for use by the CIA. The kind of tool that I am envisioning here would be a Notecards-like application, but designed to be used by multiple users (Hasasz, 1988) and with active links to the

A variety of tools are available to support the creation of dialogic documents. One approach would be to provide facilities for the audience to insert comments within an author's document, that is to provide a "peer review" (Neuwirth & Wojahn, 1996). Another is based on the notion of "group editors" (Olson & Olson, 1990), that is tools that allow multiple authors to compose a text together. Yet another approach is to move away from the production of an edited text to a more conversational mode of computer-mediated communication. This can be done either synchronously (Bateson, 1988) or asynchronously (e.g., Scardamalia & Bereiter, 1996; Chee, this volume). Integration of such tools with the previously discussed tools for organizing and composing termless papers would be welcomed.

Finally, technology can offer new ways of publishing the results of termless inquiry. The WWW is beginning to offer new possibilities for making the work of a classroom visible to the world outside of the classroom. Furthermore, publication is no longer limited to the production of static artifacts. New facilities such as MUDs and MOOs (Bruckman, 1998; Curtis, 1992; O'Day et al., 1998) offer learners opportunities to design and develop new worlds for others to interact in and with.

### **Termlessness and Current Dimensions of Educational Reform**

Termlessness can be seen to be related to a number of ideas currently being pursued in the interest of reforming educational practice. There are, of course, many kinds of educational reform. For the purposes of the current discussion, however, we will focus specifically on themes of reform based on emergent theories of learning and how it can be most effectively fostered in instructional settings (Bruer, 1993). Three such themes are Activeness, Collegiality, and Authenticity.

Traditional models of instruction based on notions of "delivery" (Newman, 1993) or "transmission" (Pea, 1996) treat the learner as a passive recipient of knowledge. One important goal of current reform is to effect a shift in the student's role from one of passivity to one that necessitates active engagement in the learning process, that is to increase student Activeness. This has been an a recurrent theme in educational reform efforts in this country for many years (Cohen, 1988; Popkewitz, 1988; Tyack & Cuban, 1995). Past innovations in instructional practice designed to increase Activeness include "learning by discovery" (Shulman, & Keisler, 1966), open-classroom learning (Kohl, 1969), experiential learning (Kolb, 1984), and inquiry learning (Bateman, 1990; Cohen, 1988). With respect to

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resources of the Web.

educational technologies, Papert (1980; 1991) has argued that engaging learners in the construction of "microworlds" and other computer-based artifacts is an excellent way of facilitating active learning.

Congruent with this movement to increase learner Activeness, another focus of change has been toward increased Collegiality in the teacher's role within the classroom (Bruffee, 1993; Mason, 1972). Traditionally, the teacher's role has been to "acquire formal knowledge, find efficient ways of sharing it, and determine whether pupils have learned what was taught" (Cuban, 1993, p. 248). Reform efforts, however, have attempted to transform this traditional role into one of team facilitator or learning coach (i.e., a transition from "the sage on the stage" to "the guide on the side"). Whereas the traditional teacher's role in recitation calls for the teacher to evaluate students' developing understanding of a topic (Mehan, 1979), alternative approaches to instruction, such as Reciprocal Teaching (Palincsar, & Brown, 1984), shift this responsibility to learners and their peers. Collaborative methods of instruction, such as some versions of Cooperative Learning (e.g., Shachar & Sharan, 1994), small-group learning (Abercrombie & Terry, 1978; Webb, 1982), "socially-assisted performance" (Tharp & Gallimore, 1988), and Problem-Based Learning (Barrows, & Tamblyn, 1980; Barrows, 1994), call for radical changes in pedagogical practice from the traditional teacher-centric model to more collegial methods of instruction. Research in the emerging area of CSCL<sup>7</sup> has focused on the ways that technology might be used to support reform on the dimension of Collegiality (Crook, 1994; Koschmann, 1996; O'Malley, 1995).

A third theme for instructional reform has been to dissolve the barriers between what one does and studies within the confines of school and the aptitudes called for in the world outside of school, that is, to increase the Authenticity of the curriculum through the design of new instructional materials and curricula (Roth, 1995). Theoretical approaches, such as Situated Cognition (Brown, Collins, & Duguid, 1989), call for increasing the resemblance between contexts of learning and contexts of application. To achieve authenticity, teaching problems, like problems in extracurricular contexts, must be complex and ill-structured, not carefully formulated 'textbook' examples (Spiro, Coulson, Feltovich, & Anderson, 1994). A variety of "case-centered" (Koschmann et al., 1996a) methods of instruction, such as

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<sup>7</sup>There is some controversy as to just what the acronym 'CSCL' should stand for (Koschmann, 1994). The standard expansion is Computer-Supported Collaborative Learning, but Pea (1996) and others have argued for alternative interpretations.

Problem- (Barrows, & Tamblyn, 1980; Barrows, 1994), and Project-Based (Blumenfeld, et al., 1991) Learning, Case Method Teaching (Kimball, 1995), Anchored Instruction (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990), Group Investigation (Sharan, & Sharan, 1992), and Case-Based Teaching (Schank, 1990) all emphasize engaging learners in authentic learning activities. Technology can and has been used in a variety of ways to support authenticity in instruction. It can, for example, increase the realism with which problems are presented to learners (Bransford et al., 1990; Koschmann et al., 1996a) or facilitate the storage and retrieval of instructive cases (Schank 1990, 1994). Technology can also support Authenticity by providing a window onto the world outside of the classroom (Riel, 1996) while at the same time, helping to make the activities of the classroom more visible to the surrounding community.

Each of these three themes can be seen as orthogonal to the other two in that each addresses a different aspect of reform. Activeness, for example, concerns changes in the role of the learner, while Collegiality is more concerned with changes in the traditional role of the teacher. Authenticity, on the other hand, is concerned with the design of new curricular structures and the materials needed to support such curricula.<sup>8</sup> Given their orthogonality, the three themes can be viewed as dimensions of a space of instructional reform, as shown in Figure 1. If we locate the traditional classroom at the origin, various proposed innovations can be plotted in this three-dimensional space. Some innovations are unidimensional in that they represent reform on only one dimension without addressing the other two. For example, some forms of contextualized learning achieve reform with respect to Authenticity, but are largely traditional with respect to Activeness and Collegiality (Williams, 1992). On the other hand, some innovations, such as Project-Based and Problem-Based Learning can be seen as multidimensional in their approach to reform, simultaneously effecting changes on two or more dimensions (Koschmann et al., 1996a).

The question might be raised, where does Termlessness fit into this multidimensional reform space? Like each of the three themes of reform previously described, one could envision a continuum of approaches varying in the

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<sup>8</sup>Note that while these three themes are orthogonal in the sense that each addresses different aspects of instruction, they are not completely independent. For example, any change to the student's role inevitably requires changes to the teacher's role and vice versa, since these roles are mutually-constitutive.

degree to which they incorporate this theme ranging from very conventional approaches to instruction that stress the acquisition of a rigidly-defined inventory of facts (c.f., Hirsch, 1987, 1996) to methods designed specifically to foster termless learning. The continuum of Termlessness, however, is not orthogonal to these previously discussed dimensions. Instead there is a reflexive relationship between Termlessness and the themes of Activeness, Collegiality, and Authenticity.

Termless instruction supports Activeness, for example, by encouraging students to take responsibility for their own learning. At the same time, Termlessness is enhanced when students assume a more active role in their education. Indeed, active learning is the only way in which learners can be prepared to become life-long and termless learners. When the teacher dictates what is to be learned, students are deprived not only of an opportunity to decide what needs to be learned, but also of an opportunity to develop skills for appraising the depth at which learning needs to be pursued.

Similarly, Termlessness supports Collegiality by calling on teachers to be themselves termless learners. In termless forms of instruction, it is not necessary for the teacher to maintain the illusion of being an all-knowing expert. Though some teachers may be reluctant to dispel this illusion, it is important that teachers serve as role models with respect to recognizing the limitations of their own understanding. Students, by the same token, are encouraged to develop their own skills for termless learning when engaged in collegial learning activities. In collaborative settings, learners are continuously called upon to display their developing understanding of an issue. By subjecting their findings and beliefs to public scrutiny, learners as a group engage in the type of critical analysis required for termless learning. Joint problem solving, therefore, provides a model of distributed appraisal that will eventually be appropriated by the individual for use in subsequent independent problem solving (Feltovich, Spiro, Coulson, & Feltovich, 1996). Skills of this type for self-appraisal are a crucial component of what we have been describing as termless learning.

Finally, termless instruction encourages learners to acquire authentic problem solving skills and to utilize authentic learning resources. Conversely, making schoolwork more closely resemble the kinds of problems one might encounter in practical contexts contributes to making students more effective learners outside of school. Termlessness, therefore, simultaneously instills and is fostered by Authenticity.

In summary, all three dimensions of reform are directed toward changes in the nature of teaching and learning that are conducive to and consistent with what has been described here as Termlessness. Because of the reflexive relationship of Termlessness to the three dimensions of reform discussed earlier, designing new technologies to support termless learning should contribute, at least in theory, to the advancement of all three themes of reform. This is not meant to suggest that designing such applications will diminish the need for more specialized tools to support, say, Collegiality or Authenticity; since such technologies are clearly needed and valuable. The advantage of focusing first on the development of tools of Termlessness, however, is that such tools can support reform in a more fundamental way than any tool designed to support instructional reform unidimensionally.

### **Concluding Thoughts**

In moving toward the development and utilization of tools of termlessness, it is important that we do not perpetuate (or worse exacerbate) the problems and inequities already attendant to the current uses of computers in education. It has been reported, for example, that students in impoverished households and school districts have less access to computers and other educational technologies than their peers in more affluent schools (Feurzig, 1997; Kozol, 1991; LCHC, 1989; Piller, 1992). Even when available, educational technology is often used in qualitatively different ways in these two settings—middle-class students using the computers in more innovative and engaging ways than students from lower-income families (Griffin, & Cole, 1987; LCHC, 1989). Further, it has been observed that, independent of socioeconomic status, female students tend to experience reduced success with instructional technologies (Scott, Cole, & Engel, 1992; Schofield, 1995; Yelland, 1994) and report less use of technology generally than their male peers (Durndell, Glissov, & Siann, 1995). Differently-abled learners, such as those with visual impairments, are also often inadvertently excluded from using certain forms of electronic content as a result of the way in which the interface to this content has been designed (National Research Council, 1997). Finally, it has been charged that the designers of educational applications have failed to recognize and accommodate for the diverse cultural identities of the learners who are ultimately expected to use their systems (Bowers, 1988; Salinas, Márquez, & León, 1995; Scott, Cole, & Engel, 1992). As designers of tools of termlessness, we must be mindful of these concerns and, where possible, seek ways of redressing them.

The notion of Termlessness is not new. As discussed earlier, it can be seen to go back at least to the writings of John Dewey at the turn of the century. Somewhat more recently Bruner (1961), in reporting the findings of a 1959 National Academy of Sciences workshop on improving science education, stated, "Mastery of the fundamental ideas of a field involves not only the grasping of general principles, but also the development of an attitude toward learning and inquiry, toward guessing and hunches, toward the possibility of solving problems on one's own" (p. 20).<sup>9</sup> Unfortunately, though these basic ideas have been around for some time, our educational policy makers have been slow to adopt them. Indeed, the current debate in the United States concerning the need for national goals and standards and a core curriculum seem to reflect an orientation toward learning that is fundamentally at odds with the spirit of Termlessness.

It is not clear what role technology can and will play in advancing the notion of Termlessness in educational practice. We do know, however, that it is only when technology is utilized in the service of a compelling set of ideas about how learning and instruction should be improved that it has any hope of achieving positive reform and I have argued that Termlessness may be one such idea. We know as well that the inertial forces that must be overcome to realize such forms of change are enormous (Papert, 1997). As Morrison and Goldberg (1996) put it, "At issue is whether the drag effect of the prevailing system of schooling—the existing set of cultural practices and beliefs that so strongly determine our collective behavior as parents, principals, school board members, students, superintendents, and teachers—is more powerful than the capacity of the new tools to catalyze change in the system" (p. 126). Whether or not the emerging tools of termlessness will be equal to this challenge remains to be seen.

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<sup>9</sup>See also Mason (1972) on "interdisciplinary enquiry."

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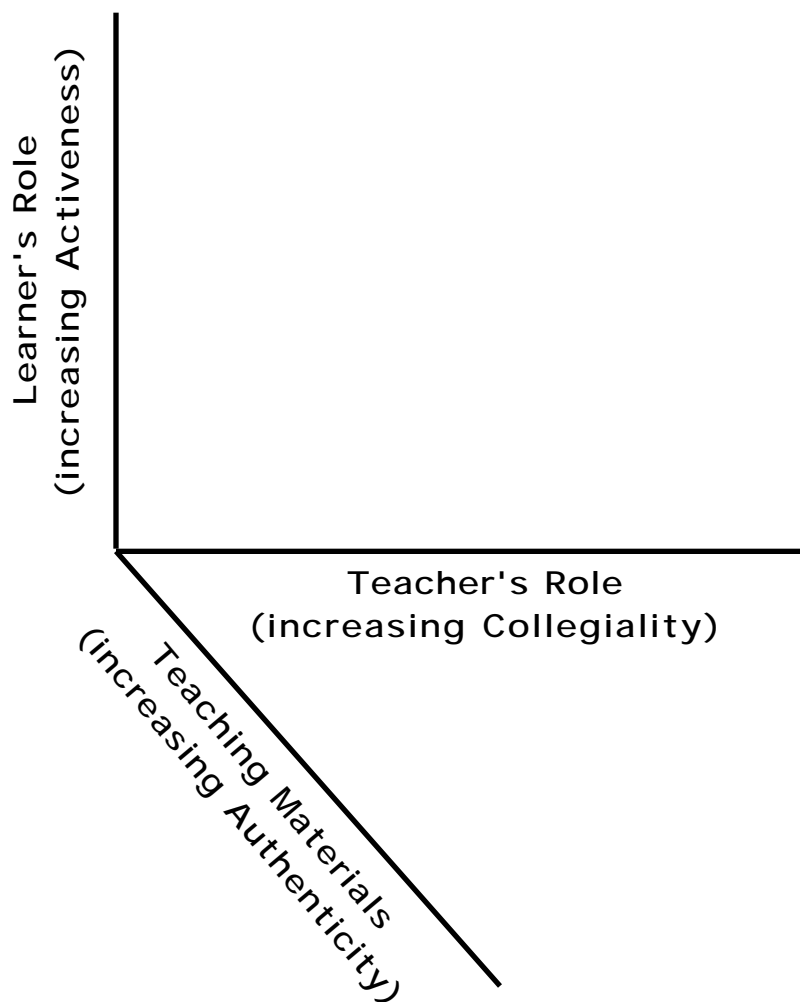


Figure 1: Some dimensions of instructional reform.