educational technology®

the magazine for managers of change in education

Volume 48, Number 3 May–June 2008

CONTENTS

Articles

Regular Features

educational technology®

Volume XLVIII
Number 3

May–June 2008

About This Issue

A general issue covering varied aspects of educational technology

Pedagogical Biases in Educational Technologies

Marlene Scardamalia
Contributing Editor

Carl Bereiter

Capabilities and biases of learning technologies are examined in light of four widely accepted principles: deep content knowledge, dialogue, agency, and collaboration. Software that supports these principles must focus students' attention on ideas rather than topics or tasks and should foster high levels of *epistemic agency*, providing students with means to assume responsibility not only for their individual contributions to knowledge in the classroom but also for the overall progress of the class's knowledge-building efforts.

Technology intended to support learning is seldom neutral with respect to pedagogy. It usually makes some things easier to do than others and thus introduces a bias toward certain kinds of activity or certain ways of going about an activity. We are not here referring to explicitly instructional technologies—drill-and-practice software, computer-assisted instruction, intelligent tutoring systems. These usually embody a clear-cut pedagogy, in the best cases supported by an explicit rationale and program of research (e.g., Anderson, Corbett, Koedinger, & Pelletier, 1995). One need not speak of 'bias' in these cases; people know what they are getting. With the advent of the personal computer and the rise of the Internet, however, new kinds of technology began to appear that are not explicitly instructional but that are often proclaimed to have important educational value. Many of these are tools taken over or adapted from non-educational applications—word processors, presentation software, multimedia authoring tools, e-mail, conferencing software, Web search engines, and the like. Although these kinds of software are typically represented as supporting a "constructivist" approach to learning, it is often not clear whether this means anything more than that the software provides students with tools for doing things. That much is self-evident and implies nothing one way or another about pedagogical biases that might be embodied in the software.

Marlene Scardamalia is the University of Toronto's Presidents' Chair in Education and Knowledge Technologies and the Director of the Institute for Knowledge Innovation and Technology at OISE/UT (*(http://ikit.org)* (e-mail: mscardamalia@kf.oise.utoronto.ca). **Carl Bereiter** is Professor Emeritus and Special Advisor to the Chief Information Officer and the Education Commons at OISE/University of Toronto (e-mail: cbereiter@oise.utoronto.ca).

Evidence that could be used to support claims of pedagogical bias is scarce, but what there is raises interesting suspicions. Here are four examples:

1. Although word processors have the potential to improve student writing by reducing mechanical burdens, investigators have found evidence of diminished planning and "an over-attendance to low level concerns, tidying up and fiddling at a local word or sentence level" (Haas, 1989, p. 96).
2. By reducing time pressure, asynchronous discussion—'threaded discourse'— ought to encourage reflection and more sustained analysis. Discussion threads, however, are notoriously short. Analyzing such discourse, Hewitt (1997) found that people tend to respond only to the most recent entries, seldom going back to pick up an older entry, and so a thread typically dies whenever the last addition to it fails to provoke responses, and overall there is less coherence than one would expect to find in an oral discussion.
3. The World Wide Web has been heralded as a vast information resource, enabling students to pursue inquiries independently and in greater depth than was possible when they had to rely on local print resources. Observing a middle-school class engaged in such inquiry, however, Moss (2000) judged that use of the Web encouraged the gathering of miscellaneous facts about a topic rather than pursuit of deeper understanding. This is what popular search engines are good at: delivering what we have called "knowledge *about*" rather than "knowledge *of*" a subject (Bereiter & Scardamalia, 2006).
4. Papert (1993) argued persuasively that children will learn more by building things than by investigating things that are already built. Operating on this premise, Yarnal and Kafai (1995) engaged students in creating educational computer games rather than in simply playing such games. The game building was part of a unit on oceans. The authors found, however, that the students (and their teacher) concentrated almost exclusively on the mechanics of game construction rather than on subject matter and that the games turned out to be factual quiz games—

quite the opposite of what a constructivist approach to learning would favor.

All of these are indications of bias, not strict limitations. The technology did not prevent people from following a high cognitive path, but it apparently tempted them and made it easier for them to take a lower path. In many schools, including ones reputed to be "innovative," the favored technology consists mainly of "productivity" applications—word processors, spreadsheets, and presentation software primarily designed for business use and frequently bundled under the name "office" (Kozma, 2003). Surely, one might suppose, such technology is pedagogically neutral, free of bias. Spreadsheets have such a variety of uses that it is difficult to generalize, but word processing and presentation software have an obvious and intentional bias toward what in movies are called "production values": the esthetics and lavishness of presentation as distinct from the quality of content. In producing a document, some attention must of course be paid to its physical appearance. In the limited time frame of most student writing, however, this amounts to attention taken away from the higher-level concerns of writing (Scardamalia, Bereiter, & Goelman, 1982). With the current enthusiasm for multimedia in schools, attention to production values could easily overwhelm attention to content, as teachers have occasionally reported to us.

Can software be designed with a bias toward high-road rather than low-road cognitive paths? Anything that facilitates contact with and attention to meanings can be counted a step in the right direction. Bromme, Hesse, and Spada (2005) have drawn together contributions from a number of researchers working on ways to facilitate "the construction of 'meaning' when information is exchanged via computers" (p. 4). Figuring prominently in these efforts are tools for representing both conceptual content and process during collaborative knowledge work. To the extent that these introduce a high-road bias, it is through providing templates that encourage and in some cases force users to categorize what they are doing at a more abstract or metacognitive level. Automatic semantic analysis is possible through Latent Semantic Analysis (Landauer & Dumais, 1997), for instance, and Web 3.0 tools such as one that can generate nodes and links of a concept map from ordinary text (Cortex Intelligence, July 3, 2007). But turning these into tools usable by students is a substantial challenge. Summary Street (Kintsch, Caccamise, Franzke, Johnson, & Dooley, 2007) uses Latent Semantic Analysis to help students improve the content of their summaries. This works nicely if the material to be summarized is provided, but if students have to go out and find the content—as is common in much project-based learning—they are at the mercy of Web search engines, which generally work by narrowing topics rather than by synthesizing meanings. Locating answers to complex or uncommon questions generally requires substantial prior knowledge of the domain in which one is searching. The "Semantic Web" is expected to do something about this, but implementation applicable to education seems to be some distance off (Borland, 2007; Maddux, 2008).

Besides semantic content, software may also support higher levels of discourse form and process. There are, for instance, argument structuring tools, mostly based on Toulmin's (1958) model of logical argument structure; e.g., Belvedere (Paolucci, Suthers, & Weiner, 1996) and SenseMaker (Bell, 1997). The low-road approach to argument structure amounts to filling in blanks, producing something that will look like an argument but that may have no coherent point. With regard to process, there is software that amounts to a "paint-by-numbers" kit for writing, but it is also possible to design software that delivers prompts and hints without micromanaging the writing process (Rowley & Meyer, 2003; Zellermayer, Saloman, Globerson, & Givon, 1991). Blocking low-level processes is also a possibility, although one that has not been implemented in software as far as we know. In order to block low-level "tidying up and fiddling," for instance, font choices could be disabled until a late stage in the composing process (Goldfine, 2001). Any technology intended to promote a high-road path to content, structure, or process must walk a fine pedagogical line. The high road, we might say, is a very narrow path, with ever-present risk of micromanagement and dumbing-down on one side and insufficient support on the other.

A Principled Approach to Pedagogical Design of Software Learning Environments

Although formulations differ, there is a set of principles endorsed by a broad spectrum of educators and educational researchers that educational technology designers might all find easy to endorse. Some of the principles, such as "active learning," are so general that almost any interactive software would satisfy them. The following four principles, however, have some bite. They are not easily achieved in any case, and it is not so obvious how technology could help:

1. ***Depth of learning.*** This is an objective of practically every cognitively-oriented educational approach and is one of the main ideas informing Bransford, Brown, and Cocking's *How People Learn* (1999). Failures to achieve depth of learning are evident from the research on enduring misconceptions and from international assessments in science and mathematics. Although depth is difficult to define, in formal education contexts, it implies contact with

recognized deep principles of the disciplines (Bereiter, 2006; Brown & Campione, 1996). It also implies a progressive process, using the understandings gained from inquiry to formulate new problems and questions that could not have been formulated before (Bereiter & Scardamalia, 1993; Hakkarainen & Sintonen, 2002).

2. ***Discourse.*** We agree with Brown and Campione (1996) that discourse is central to knowledge advancement. It is, of course, the primary way of sharing knowledge and resolving differences, but its importance is more fundamental than that. One way of putting it is that first-hand experience, through experimentation, observation, and the like, as well as reading and browsing the Web, provide information, not knowledge. Converting such information into knowledge is a reflective process that is fundamentally dialogic. Dialogue with oneself is a possibility, but, especially in schools, interpersonal dialogue is the only practical way of processing information into knowledge. And not all forms of dialogue will do. Below, we turn our attention to dialogue particularly conducive to knowledge advancement.
3. ***Higher levels of agency.*** This implies something beyond students enjoying the right to choose or plan their own activities, enter into learning contracts, and other well-recognized forms of classroom democracy. It implies turning over to the students parts of the educational process that are normally reserved for the teacher, even in so-called learner-centered classrooms (Bereiter & Scardamalia, 1987; Scardamalia & Bereiter, 1991). This implies a high level of metacognitive engagement (Brown & Campione, 1996). Beyond that, what we have defined as *epistemic agency* entails students' taking responsibility for the advancement not only of their personal knowledge but that of the classroom community as a whole (Scardamalia, 2002).
4. ***Collaboration.*** Collaboration has become something of a mantra for Knowledge Age education. It appears everywhere in curriculum standards and guidelines and in the writings of business pundits. And of course it is institutionalized in "Computer Supported Collaborative Learning," an avant-garde community of technology developers and users. Perhaps the most notable shift in instructional psychology during the last quarter of the 20th century was the shift from focus on individual cognitive strategies to focus on community, culture, and collaboration. An older idea, cooperative learning, retained the individualistic focus as far as outcomes were concerned: it involved students working together to achieve individual learning objectives. Among Learning Scientists, collaboration is conceived of as extending beyond cooperative learning and also beyond collaboration in concrete tasks to collaboration in the pursuit of shared epistemic objectives: hence, "collaborative inquiry" (Suthers, Toth, & Weiner, 1997), "distributed expertise" (Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1993), and "collective cognitive responsibility for the advancement of knowledge" (Scardamalia, 2002).

Software can be found that undermines or at least fails to support these principles. Presentation software and "mind mapping" tools encourage reduction of a complex topic to phrases and labels. The default structure of PowerPoint slides is hierarchical decomposition into lists and sublists—not likely to be the best way to guide deep inquiry. The typical "mind map" is just a hierarchical list presented in a different format. It has been reported that a warning about the danger of insulation coming loose was contained in a slide presentation to NASA executives before the Challenger disaster, but it occurred far down in a list and was accordingly ignored. Software to guide inquiry projects can micromanage the process, reducing students' input to little more than filling in blanks. Creative knowledge work, which can move in unpredictable directions, has proved difficult to support with software. Collaborative writing software and wikis facilitate local revisions, additions, and deletions, but offer little encouragement for global rethinking and revision. But what would technology be like that supported the four principles? That is the question we pursue in the remainder of this article.

In the following sections we take up the principles in order, first providing a general discussion of their design implications and of the common technological approaches to them, then explaining how we addressed these principles in the design of Knowledge Forum® and its predecessor, CSILE (Computer Supported Intentional Learning Environment). The heart of CSILE/Knowledge Forum is a multimedia community knowledge base. In the form of notes, participants contribute theories, working models, plans, evidence, reference material, and so forth, to this shared space. The software provides knowledge-building supports both in the creation of notes and in the ways they can be displayed, linked, and made objects of further work. Revisions, elaborations, and reorganizations over time provide a record of group advances, like the accumulation of research advances in a scholarly discipline.

Depth of Learning: Representing and Working with the Big Ideas

Engagement with deep ideas as objects of inquiry is by no means easy to accomplish. Everyone thinks about the world, but not everyone thinks about ideas about the world. The difference may be illustrated with one of the really big ideas, natural selection. When it enters into school discourse, it usually represents a belief about evolution. It vies with Lamarkism and creationism, frequently losing the contest in the minds of the students. This is thinking about the world—about the diversity of species, about biological adaptation, and about what actually happened in the distant past. But natural selection is an extraordinarily powerful idea in its own right, by no means limited to theorizing about the origin of species. It figures in explanations of drug-resistant germs and insecticide-resistant insects, the functioning of the immune system, knowledge evolution and diffusion, learning and creativity. A focus on the idea and on what it is good for, its strengths and limitations, would constitute quite a different curriculum element from the standard topical unit.

Focusing on ideas rather than generic topics also calls for a different kind of technology from the topical unit. Web search engines, encyclopedias, and book indexes are all suited to finding information on generic topics but are unhandy for tracking down explanations and underlying principles. Hierarchical decomposition into subtopics is the dominant structural concept throughout, and the "ontologies" that figure in Web 3.0 designs generally perpetuate this structure. A search engine for "thoughts" would need to go beyond finding documents that address the topics you are thinking about and find instances of thinking along the same or divergent or opposing lines. For such purposes, many people are reportedly finding the social networking supports of Web 2.0 more useful.

This suggests that if you are looking for complex information, it may be easier to find a person who has that information than to find it by searching documents. Within classrooms or other relatively small interacting groups, however, the problem is not so much idea search as idea fore-grounding and idea development over time. For these purposes, *dialogue* support becomes the key—as it has been since the time of Socrates.

Making ideas objects of inquiry means treating them as real things in the Popperian sense (Popper, 1972): that is, treating them as products of intentional activity which, though immaterial, enjoy existence in their own right, apart from the people who happen to believe or be thinking about them. "Conceptual artifacts" is the term we prefer to Popper's "objective knowledge" (Bereiter, 2002). What fundamentally sets conceptual artifacts apart from other artifacts is the logical relations that may obtain among them. One idea may imply, contradict, represent a special case or a generalization of another, and so on—literal relations that are to be found only figuratively among other kinds of artifacts.

Software intended for work with ideas should, accordingly, provide ways of representing and working with these logical relations. Concept nets are a popular way of representing part-whole relations, causal relations, implicative relations, and so on. Software is available that facilitates producing box-and-link diagrams, preserving the links as boxes are shifted around. A sizeable literature has grown up around the educational use of such diagrams. Certainly one important part of concept learning, especially in science, is learning how concepts are interrelated, and there is evidence that judicious work with concept nets can accomplish this (Jonassen, Reeves, Hong, Harvey, & Peers, 1997). However, there is more to ideas than their interrelationships. The philosopher Mario Bunge (1977–1979) said of theories that they can be variously treated as "ideal objects, systems of changeable meaning and truth value, growing bodies of knowledge, or prescriptions for doing things." Of particular importance in education is the explanatory role of concepts, theories, and the like. As Popper (1962) urged, the first thing you need to understand about a theory is the problem it is intended to solve. Concept nets do not convey what the whole network of concepts is for nor do they provide a very rich account of what any particular concept is for. And they are relatively useless for comparing one idea or theory with another. This is not to take away from the valuable role they do play, but it does suggest that many educators have been oversold—especially on so-called "mind maps" that link concepts without identifying the relationships.

In Knowledge Forum we provide open and versatile means for representing higher-level organizations of ideas. A "view" in Knowledge Forum provides a graphical background upon which individual notes can be arranged in any way. The background can be anything the designers (who are typically the students themselves) create: a scene, a set of categories, a narrative sequence—or, for that matter, a concept net. In particular, a view can represent graphically the big ideas that frame an inquiry. Views can be linked to other views and can be subsumed by still higher-level views. A particular note can appear in more than one view. Thus, multiple forms of representation are possible, providing different perspectives on the big ideas.

Knowledge-Building Discourse

Technology to support educative dialogue may be divided into two types: discussion software, for posting and responding to messages, and software designed to give some structure to discourse. The former is by far the most widely used, existing sometimes as a free-standing "forum" and sometimes as an add-on to a different kind of software, which may be a course delivery system, a game, a simulation, a document management system, or even an online newspaper column. The technology generally ranges from primitive to extremely primitive. In extremely primitive versions, the messages appear one after another in chronological order and it is often a challenge to figure out what someone is talking about, because their message refers to an unidentified message some distance back in the queue. The merely primitive technology allows comments to be directly attached to the message being commented on, for comments on comments, and so on, to create a "thread," which usually appears on screen as an indented list. Anyone who has tried to carry on an intelligent discussion in such a medium will have been thwarted by the inability to link to notes in different threads or to make an entry that is superordinate to rather than subordinate to what is already there. Progress is inexorably downward in a branching hierarchy, which turns such vital operations as synthesis into a battle with the technology. What the technology does support very well is what it was originally designed to support: brief question-answer and opinion-response exchanges. Its unmodified transition from Web forums devoted to people's problems laying floor tile to educational forums devoted to students' problems understanding Newton's Third Law stands as a prime illustration of consumers' uncritical acceptance of whatever meets standards of usability.

Unlike the message-based systems we have been discussing, technology designed to assist reflective discourse generally has some theoretical basis. There is, however, an interesting divergence. One kind of application, referred to earlier, mainly supports argumentation. The other kind mainly supports explanation-oriented discourse. In recent years researchers working in the argumentation tradition have expanded the concept to include "collaborative argumentation" and "arguing to learn" (Andriessen, Baker, & Suthers, 2003). However, both in terms of analysis and in terms of technological supports, argumentation still carries an emphasis on confrontation and persuasion, whereas explanation-oriented discourse emphasizes working together toward a shared creative goal—to achieve some level of what Thagard (1989) has termed "explanatory coherence."

Both controversy and collaborative explanation are important in disciplined knowledge building, of course. As Woodruff and Meyer (1997) argued, however, they occur in different phases of knowledge development and can involve different communities. Argumentation tends to characterize interchanges between large communities (such as scientific societies) and occurs after theories or claims have been developed to the point that differences are clear; collaborative, explanation-oriented interchanges tend to characterize knowledge work within local groups, such as laboratory teams, and plays its main role in creating new knowledge rather than in deciding among competing ideas. On this analysis, the school situation is one in which collaborative, explanation-oriented discourse is much more appropriate than argumentation (cf. Coleman, 1998; Coleman, Brown, & Rivkin, 1997), although flexible movement between both forms of discourse is needed for knowledge advancement.

Knowledge Forum has been designed as a general-purpose collaborative knowledge-building environment with a special emphasis on discourse. One of the original intentions in design of its predecessor, CSILE, was to change the flow of discourse in the classroom so that it did not all pass through the teacher (Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989). This has meant walking the narrow path referred to earlier, between providing too little structure and too much and enabling the teacher to exert positive influence without micromanaging the discourse. Thus, Knowledge Forum provides "scaffolds" (phrases indicating type of idea or contribution) but instead of requiring them to be used—and even requiring them to be used in a certain order—as other collaborative environments do, we made them optional, modifiable, but attractive as labor-saving devices (clicking on a scaffold pops it as highlighted text into the note being composed, thus saving on typing). Graphics, video notes, and other means of representing ideas can be brought into Knowledge Forum notes, thus expanding the discourse possibilities beyond those afforded by written text. Scaffolds are modifiable. Although a set of theory-building supports ("My theory…," "This theory does not explain…," "A better theory…," and so forth) has proved remarkably versatile in its applicability to different knowledge-building efforts, some teachers have used scaffolds designed to support argumentation (they lend themselves nicely to Toulmin's model) and such specialized tasks as medical diagnosis. Students, once they become immersed in knowledge building, will sometimes suggest scaffold revisions to reflect their growing epistemic agency.

Online discussions are often looked on as pale substitutes for face-to-face discourse, and it is surely true that they lack the vigor and multi-level character that gesture and vocal expression give to conversation. Rather than struggling to achieve closer emulation of face-to-face discourse, however, we have tried in Knowledge Forum to capitalize on the advantages that technology offers: the ability to focus on ideas rather than on the speaker, the ability to revise and undo, the ability to connect anything with anything and to overcome chronological sequence in doing so, the ability to create alternative organizations, the ability of one contribution to exist in different contexts, the ability to produce a synthesis of existing discourse elements, the ability to represent metadiscourse so that it is connected with but not muddled with the basic discourse (cf. Suthers, 2005). There is a great deal of room here for invention, experimentation, and theorizing, which opens up once dialogue is viewed as an interaction among ideas and not solely or even primarily as an interaction among speakers.

Higher Levels of Agency: Kid-Level Knowledge Management

To consider "agency" as it relates to educational environments, we need to distinguish classrooms organized around activities from classrooms organized around ideas. There are, of course, other things classroom life can be organized around, but classrooms purported to take a constructivist approach can be fairly well covered by these two types of organization, with organization around activities being by far the most common. When classroom life is organized around activities, "agency" usually has a clear and easily specified meaning. It means the extent of autonomy students have in the choice, design, and management of activities. Where the activity is building things out of LegoLogo, for instance, one can find some classrooms in which the students have virtually no agency: cards accompanying the product specify step-by-step procedures for building various interesting devices, and the students slavishly follow those procedures. But there are other classrooms in which the students produce their own designs and manage collaborations themselves. (That both of these approaches should be called "constructivist" or "constructionist" seems to us to make a mockery of these terms.)

When classroom work is organized around ideas, "agency" takes on a different and less easily specifiable meaning. Relevant considerations are (a) the extent to which students' own ideas are given prominence, (b) the extent to which students take responsibility for improving their ideas and those of their peers, (c) the extent to which students are responsible for seeking out information (experimental, authoritative, etc.) needed to improve their ideas, (d) the extent to which students are responsible for connecting their work to the knowledge objectives set forth in official guidelines and standards, and (e) the extent to which organization and management of the whole idea-generating and idea-improvement process are in the hands of the students. Technology can support all these aspects of epistemic agency. Details can be found in Scardamalia (2002) and Scardamalia (2003). Here we will offer just one example: Knowledge Forum views, as described in an earlier section, require management. If a large number of notes are placed in a view, if their arrangement is left to individual whim, and if the graphical background is merely decorative rather than conceptually useful, the result can be distressing clutter. Several teachers have turned the management of each view over to a small committee of students. The teacher encourages them to attend not only to neatness and order but also to designing and managing the view so as to promote knowledge advancement. Students tend to take this role seriously; recorded discussions show them arguing about what to do with redundant notes and how to advance collective goals without trampling over individual sensitivities. This is authentic knowledge management, comparable to what goes on in the business world. It additionally encourages meta-discourse: reviewing ideas, "rising above" first efforts, and creating increasingly coherent conceptual frameworks for knowledge advances.

Supporting the Ethos of a Scholarly Community

Scholarly and scientific communities have evolved certain social forms that help to maintain the delicate balance between individual interests (tenure, recognition, etc.) and collective interests in advancing the state of knowledge. Educational technology tends to err in putting most of the emphasis on individual interests, perhaps reflecting a belief that youthful egos require exceptional nurturance. Supportive procedures range from miniature portraits adorning student contributions in a discussion forum to the full-scale creation of personal blogs or Web pages for every student, containing whatever the students care to display about themselves. Scholarly communities find more subtle ways to satisfy the ego-needs of members, ways that advance rather than deflect collective knowledge-advancement. Among these are citation and reference, humane peer review, and (to borrow a term from the business community) "incubation."

Citation and Reference

Scholars acknowledge and reference their sources, according to rigid formulas that vary from discipline to discipline. If they fail to do so, they too are liable to accusations of plagiarism. Referencing is tedious business, lightened by bibliographic software. In Knowledge Forum we have tried to lighten the burden even more, at least when it comes to citing information from other notes in the database. A note or a highlighted excerpt can be dragged into another note. There it appears in a distinctive font and a bibliographic reference is automatically generated. Future versions of Knowledge Forum are expected to extend this function to material copied from other sources, including the Web. The goal is to create a bias favorable to a reference-and-contribute approach to the use of authoritative sources, rather than the copy-delete approach that Brown and Day (1983) identified with immature writers.

Humane Peer Review

Peer review, as applied to publication, awarding of grants, and many other decision points in scholarly life, is generally discussed in terms of quality control. Like democracy, it is recognized to have many faults but is judged to be better than the alternatives. Less generally recognized are the lengths scholarly communities go to maintain a sense of fairness, to ease the pain of rejection, and to use the peer review process constructively, as a form of mentorship. Quality control is highly dependent on the general state of development of the scholarly community, which raises question about the extent to which peer review among students will suffice. Furthermore, students will not have been schooled in the etiquette of peer review. We have worked in schools where sarcasm and put-downs were a normal part of both online and offline discourse.

Technology cannot, of course, make subject-matter experts out of novices or induce constructive criticism. Those are jobs for the whole educational program. In modest ways it can assist. In Knowledge Forum the main way this is done is through scaffolds and other devices that focus attention on ideas and minimize tendencies toward *ad hominem* judgment. Our own feeling is that in a healthy classroom there is little danger of personality and sociality getting lost; what's needed, rather, is a compensating bias toward treating ideas as having a life of their own. The desirable balance is illustrated in one extended discourse on growth, in which a student advanced a fanciful notion about cross-breeding plants and animals. The idea aroused considerable interest but was subjected to a devastating though polite critique by one class member. To this, the original author responded, "Geeeze Mike, I like all your comments, but it was just a theory!" (Bereiter, Scardamalia, Cassells, & Hewitt, 1997).

Incubation

To help new businesses get started, for-profit and not-for-profit institutions have been established that are called "incubators." Here the novice entrepreneur can take advantage of an existing well-equipped infrastructure, be shielded from many of the concerns that normally beset a business, and sometimes receive advice, training, and mentorship. Knowledge creation needs incubation in this sense, too, as well as in the more familiar sense of having time for ideas to mature before emerging from the shell.

In the sciences, publicly supported research laboratories almost always have an incubator function. Doing a post-doctorate in one of the laboratories has become almost an essential stepping-stone to a high-status academic position. But what would an incubator be like for earlier stages of educational development? An incubator for schools needs to be an environment in which ideas can develop with freedom from premature judgment but without being isolated from external sources of ideas and information. So again there is a question of balance. In classrooms using Knowledge Forum we have seen examples of imbalance in either direction. We have seen cases in which students' own ideas were allowed to proliferate without any effort to find out what the outside world knows and thinks. We have also seen instances in which early exposure to canonical knowledge squelches inquiry: "My theory was wrong. The correct explanation is...." The desirable balance depends on the subject matter and the knowledge students bring in with them. The design challenges are ones we have discussed elsewhere as "improvable ideas" and "constructive use of authoritative sources" (Scardamalia, 2002).

The ideal software environment will allow students to find their own shifting balance between too much outside information and too little, indulgence and criticism, mutual support and argument. Clearly an environment that micromanages and over-prescribes, the way many instructional environments do, does not encourage such self-organizing processes. Neither, however, do virtually structureless environments, such as blogs, which are gaining popularity for classroom use and which simply arrange contributions in chronological order. Our strategy in designing Knowledge Forum, as already suggested, is to make it possible for the students themselves to build structure as their need and capacity to envision it increase.

Conclusion

The design of educational technology ought to be seen as a part of instructional design rather than only as a source of tools for use in instruction. The Learning Sciences were founded on this belief, and many kinds of software have come out of research programs primarily concerned with educational rather than technological innovation. Nevertheless, most of the information and communication technology used in schools has its origins outside the Learning Sciences and tends to be assimilated to conventional practices rather than advancing the state of the art in education. In this article we examined capabilities and biases of learning technologies in light of four principles that have gained wide acceptance in the Learning Sciences: deep content knowledge, dialogue, agency, and collaboration. The following are some of the design characteristics that should create biases favorable to these principles in any online learning environment:

- In order to encourage the pursuit of **deep content knowledge**, provide means at any point in online work to move up to a more inclusive and integrative level of analysis, down to a more detailed level, or sideways to analogous ideas.
- In order to encourage **knowledge-building dialogue**, provide flexible supports that focus attention on ideational content rather than on utterance.

- In order to foster **higher levels of epistemic agency**, make it possible for students to function as “knowledge managers” or “knowledge enablers” (von Krogh, Ichijo, & Nonaka, 2000). That is, provide them with the means to assume responsibility not only for their individual contributions to knowledge in the classroom but for the overall progress of the class’s knowledge-building efforts.
- In order to foster epistemically productive **collaboration** through online knowledge work, provide convenient and professional ways for students to cite and link to one another’s work, thereby building a knowledge structure that represents the collective progress of the community rather than only the work of individual students or teams. □

References

Anderson, J. R., Corbett, A. T., Koedinger, K., & Pelletier, R. (1995). Cognitive tutors. Lessons learned. *The Journal of the Learning Sciences, 4*(2), 167–207.

Andriessen, J., Baker, M., &Suthers, D. (Eds.). (2003). *Arguing to learn: Confronting cognitions in computer-supported collaborative learning environments*. Dordrecht: Kluwer.

Bell, P. (1997). Using argument representations to make thinking visible for individuals and groups. In R. Hall, N. Miyake, & N. Enyedy (Eds.), *Proceedings of CSCL ‘97: The Second International Conference on Computer Support for Collaborative Learning* (pp. 10–19). Toronto: University of Toronto Press.

Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bereiter, C. (2006). Reflections on depth. In K. Leithwood, P. McAdie, N. Bascia, & A. Rodrigue (Eds.), *Teaching for deep understanding: What every educator should know* (pp. 11–16). Thousand Oaks, CA: Corwin Press.

Bereiter, C., & Scardamalia, M. (1987). An attainable version of high literacy: Approaches to teaching higher-order skills in reading and writing. *Curriculum Inquiry, 17*(1), 9–30.

Bereiter, C., & Scardamalia, M. (1993). *Surpassing ourselves: An inquiry into the nature and implications of expertise*. La Salle, IL: Open Court.

Bereiter, C., & Scardamalia, M. (2006). Education for the knowledge age: Design-centered models of teaching and instruction. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 695–713). Mahwah, NJ: Lawrence Erlbaum Associates.

Bereiter, C., Scardamalia, M., Cassells, C., & Hewitt, J. (1997). Postmodernism, knowledge building, and elementary science. *Elementary School Journal, 97*, 329–340.

Borland, J. (2007, March/April). A smarter web. *Technology Review; http://www.technologyreview.com/Infotech/18306/* .

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academies Press.

Bromme, R., Hesse, F., & Spada, H. (Eds.). (2005). *Barriers and biases in computer-mediated knowledge communication, and how they may be overcome* (pp. 295–319). New York: Springer.

Brown, A. L., & Day, J. D. (1983). Macrorules for summarizing texts: The development of expertise. *Journal of Verbal Learning and Verbal Behavior, 22*, 1–14.

Brown, A., Ash, D., Rutherford, M., Nakagawa, K., Gordon, A., & Campione, J. C. (1993). Distributed expertise in the classroom. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 188–228). New York: Cambridge University Press.

Brown, A. L., & Campione, J. C. (1996). Psychological theory and design of innovative learning environments: On procedures, principles, and systems. In L. Schauble & R. Glaser (Eds.), *Innovations in learning: New environments for education* (pp. 289–325). Mahwah, NJ: Lawrence Erlbaum Associates.

Bunge, M. A. (1977–79). *Ontology: Treatise on basic philosophy*. Boston: Reidel.

Coleman, E. B. (1998). Using explanatory knowledge during collaborative problem solving in science. *The Journal of the Learning Sciences, 7*(3&4), 387–427

Coleman, E. B., Brown, A. L., & Rivkin, I. D. (1997). The effect of instructional explanations on learning from scientific texts. *The Journal of the Learning Sciences, 6*(4), 347–365.

Cortex Intelligence. (2007, July 3). Web 3.0 demo; *http://www.cortex-intelligence.com/tech/* .

Goldfine, R. (2001). *Making word processing more effective in the composition classroom*. Urbana, IL: National Council of Teachers of English.

Haas, C. (1989). Does the medium make a difference? Two studies of writing with pen and paper and with computers. *Human-Computer Interaction, 4*, 149–169.

Hakkarainen, K., & Sintonen, M. (2002). Interrogative model of inquiry and computer-supported collaborative learning. *Science & Education, 11*, 25–43.

Hewitt, J. (1997). Beyond threaded discourse. Paper presented at WebNet ‘97; *http//:csile.oise.utoronto.ca/csile_biblio.html* .

Jonassen, D. H., Reeves, T. C., Hong, N., Harvey, D., & Peers, K. (1997). Concept mapping as cognitive learning and assessment tools. *Journal of Interactive Learning Research, 8*(3/4), 289–308.

Kintsch, E., Caccamise, D., Franzke, M., Johnson, N., & Dooley, S. (2007). Summary Street® : Computer-guided summary writing. In T. K. Landauer, D. M. McNamara, S. Dennis, & W. Kintsch (Eds.), *Latent semantic analysis* (pp. 263–277). Mahwah, NJ: Lawrence Erlbaum Associates.

Kozma, R. B. (Ed.). (2003). *Technology, innovation, and educational change: A global perspective*. Eugene, OR: ISTE.

Landauer, T. K., & Dumais, S. T. (1997). A solution to Plato’s problem: The Latent Semantic Analysis theory of the acquisition, induction, and representation of knowledge. *Psychological Review, 25*, 211–240.

Maddux, C. D. (2008, Jan.–Feb.). The Semantic Web and educational technology. *Educational Technology, 48*(1), 3–9.

Moss, D. M. (2000). Bringing together technology and students: Examining the use of technology in a project-based class. *Journal of Educational Computing Research, 22*(2), 155–169.

Paolucci, M., Suthers, D., & Weiner, A. (1996). Automated advice-giving strategies for scientific inquiry. In C. Frasson,

G. Gauthier, & A. Lesgold (Eds.), *Intelligent tutoring systems. Lecture notes in computer science, No. 1084* (pp. 372–381). Berlin: Springer-Verlag.
Papert, S. (1993). *The children's machine*. New York: Basic Books.
Popper, K. (1962). *Conjectures and refutations: The growth of scientific knowledge*. New York: Basic Books.
Popper, K. R. (1972). *Objective knowledge: An evolutionary approach*. Oxford: Clarendon Press.
Rowley, K., & Meyer, N. (2003). The effect of a computer tutor for writers on student writing achievement. *Journal of Educational Computing Research, 29*(2), 169–187.
Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 76–98). Chicago: Open Court.
Scardamalia, M. (2003). Knowledge-building environments: Extending the limits of the possible in education and knowledge work. In A. DiStefano, K. E. Rudestam, & R. Silverman (Eds.), *Encyclopedia of distributed learning* (pp. 269–272). Thousand Oaks, CA: Sage Publications.
Scardamalia, M., & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media. *The Journal of the Learning Sciences, 1*(1), 37–68.
Scardamalia, M., Bereiter, C., & Goelman, H. (1982). The role of production factors in writing ability. In M. Nystrand (Ed.), *What writers know: The language, process, and structure of written discourse* (pp. 173–210). New York: Academic Press.
Scardamalia, M., Bereiter, C., McLean, R. S., Swallow, J., & Woodruff, E. (1989). Computer-supported intentional learning environments. *Journal of Educational Computing Research, 5*, 51–68.
Suthers, D. (2005). Technology affordances for intersubjective learning, and how they may be exploited. In R. Bromme, F. Hesse, & H. Spada (Eds.), *Barriers and biases in computer-mediated knowledge communication, and how they may be overcome* (pp. 295–319.) New York: Springer.
Suthers, D., Toth, E., & Weiner, A. (1997). An integrated approach to implementing collaborative inquiry in the classroom. *Proc. 2nd Int. Conf. on Computer Supported Collaborative Learning* (CSCL'97), Toronto, December 10–14, 272–279.
Thagard, P. (1989). Explanatory coherence. *Behavioral and Brain Sciences, 12*, 435–502.
Toulmin, S. (1958). *The uses of argument*. Cambridge, UK: Cambridge University Press.
von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation*. New York: Oxford University Press.
Woodruff, E., & Meyer, K. (1997). Explanations from intra- and inter-group discourse: Students building knowledge in the science classroom. *Research in Science Education, 27*(1), 25–39.
Yarnall, L., & Kafai, Y. (1996, April). Issues in project-based science activities: Children's constructions of ocean software games, American Educational Research Association, New York; *http://www.gse.ucla.edu/kafai/Paper_Kafai%2FYarnall.html* .
Zellermayer, M., Salomon, G., Globerson, T., & Givon, H. (1991). Enhancing writing-related metacognitions through a computerized writing partner. *American Educational Research Journal, 28*(2), 373–391.

Enhancing Distance Learning for Today's Youth with Learner-Centered Principles

Wallace H. Hannum
Contributing Editor

Barbara L. McCombs

Providing a research-validated, evidence-based framework for designing effective distance learning experiences and environments is a current challenge to those interested in using this technology effectively with adolescents. This article offers the Learner-Centered Psychological Principles (LCPs) developed and disseminated by the American Psychological Association as a framework for developing design principles for distance learning for use in high schools. The argument is made and supported by research that today's youth are increasingly disengaged from traditional forms of instruction, and unless distance learning can offer an alternative paradigm that meets their learning needs, the potential of distance learning will not be realized. More importantly, this technology alone will not address the needs of today's youth to be prepared with 21st century skills for a global world. The authors describe how the LCPs can be used to define not only new design principles for distance learning but also a new educational paradigm.

Introduction

Purpose

The premise of this article is that the full potential of distance learning in all its forms and applications

Wallace H. Hannum is Associate Professor in the School of Education and the Associate Director for Technology of the National Research Center on Rural Education Support at the University of North Carolina, Chapel Hill (e-mail: hannum@unc.edu). **Barbara L. McCombs** is a Senior Research Scientist with the Denver Research Institute, Denver, Colorado (e-mail: barbara.mccombs@du.edu). The authors are listed in alphabetical order; both contributed equally to the development of this article.

The person serving as facilitator may be a librarian, media specialist, assistant principal, coach, or other adult. It does not need to be a teacher, since the role of a facilitator is to support the learner and not to "teach" the content. The distance learning teacher does all the instructing. Often in these situations the facilitator does little more than ensure that the technology is working, the students are able to sign-on their courses, and the room is quiet and orderly. We believe that this approach represents a significant lost opportunity in distance learning courses. The facilitators are already employed and present in many high schools that offer distance learning courses. The additional time and expense of providing some training in using the LCPs is minimal. Even if distance learning courses had the very best of teachers, it would be difficult, if not impossible, for these teachers to implement fully the LCPs at a distance. We believe this requires having a facilitator at the local school in the room with the students to support their participation in the distance learning course. This support can take many forms, as is suggested by the LCPs. The facilitator can also serve as the eyes and ears of the distance learning teacher to provide him or her with much needed feedback about the students. The facilitator helps the learners engage with other learners online to forge stronger relationships and connections while creating online learning communities that support their academic progress.

Our experience is that even with limited training in use of the Learner-Centered Principles, the facilitators can be instrumental in implementing LCPs at the local level and thus improve the quality of the overall learning experience. Facilitators can help support and scaffold the learning of their students, while finding ways to adapt the course content to the individual differences and needs of their learners. The facilitator can work to find that delicate balance between freedom and control that is so vital to meaningful learning. This will help keep the learners from being overwhelmed by the requirements of a distance learning course while ensuring that they are not merely passive recipients of information transmitted over the Internet.

Facilitators can assist learners not only with any potential technical problem but also assist them in developing more sophisticated learning strategies and in enhancing their metacognitive awareness. The facilitator can also have an active role in alerting the teacher when problems are arising that the teacher may not be aware of due to his or her physical separation. When local facilitators have received some training and support in using the LCPs, we have found that their students are much less likely to drop out of the distance learning course, when compared to students who are in courses that the facilitators have not been trained in LCP use. In short, we believe that introducing the facilitators to the learner-centered principles will have positive effects over and beyond what is achieved by the distance learning teachers.

Summary

The learner-centered framework thus provides a foundation for transforming education and the role of distance learning. Many of those closely associated with the application and assessment of technology in education recognize that the current system must be transformed to accommodate the changing needs in our world, our technologies, and what students need to succeed and help shape the future (e.g., Levine, 2007; Stewart, 2007; Suarez-Orozco & Sattin, 2007). Technology can change the role of teachers to that of co-learners and contributors to the social and interpersonal development of students, counterbalancing the potential of computer technology to lead to personal and social isolation and alienation. Technology can further promote student connections to the community around them and to working in groups on real-world projects across time and space. Online delivery of education can then provide a means to centralize course development so that it achieves necessary economies of scale while linking intergenerational learners, teachers, and facilitators on a global scale. Rigorous research in all these areas is beginning to emerge (e.g., Duffy & Kirkley, 2004; Penuel & Riel, 2007) but more research needs to be done to systematically address the above issues and the critical features needed for effective distance learning. □

References

Alexander, P. A., & Murphy, P. K. (1998). The research base for APA's learner-centered principles. In N. M. Lambert & B. L. McCombs (Eds.), *Issues in school reform: A sampler of psychological perspectives on learner-centered schools* (pp. 25–60). Washington, DC: American Psychological Association.

Allen, M., Mabry, E., Mattrey, M., Bourhis, J., Titsworth, S., & Burrell, N. (2004). Evaluating the effectiveness of distance learning: A comparison using meta-analysis. *Journal of Communication, 54*(3), 402–420.

Allen, I. E., & Seaman, J. (2007). *Online nation: Five years of growth in online learning*. Needham, MA: Sloan Consortium.

APA Task Force on Psychology in Education. (1993, January). *Learner-centered psychological principles: Guidelines for school redesign and reform.* Washington, DC: American Psychological Association and Mid-Continent Regional Educational Laboratory.

APA Work Group of the Board of Educational Affairs. (1997, November). *Learner-centered psychological principles: A framework for school reform and redesign*. Washington, DC: American Psychological Association.

Beffa-Negrini, P. A., Miller, B., & Cohen, N. (2002). Factors related to success and satisfaction in online learning.