Education and Technology

An Encyclopedia

Volume Two | J – Z

Ann Kovalchick and
Kara Dawson, Editors

Garvin, David. 1998. "Building a Learning Organization." In *Harvard Business Review on Knowledge Management* (pp. 47–80). Boston: Harvard Business Review.

Quinn, J., A. Anderson, and S. Finkelstein. 1998. "Managing Professional Intellect: Making the Most of the Best." In *Harvard Business Review on Knowledge Management* (pp. 181–206). Boston: Harvard Business Review.

Tiwani, Amrit. 1999. *The Knowledge Management Toolkit: Practical Techniques for Building a Knowledge Management System.* Upper Saddle River, NJ: Prentice-Hall.

Knowledge-Building Environments (KBEs)

Almost all of the innovative work in the learning sciences and instructional design today comes from the constructivist paradigm, in which knowledge is viewed as humanly constructed. When compared to conventional instructivist pedagogy, the various constructivist approaches appear to be fundamentally the same. Yet there is reason to believe that there are deep differences among constructivist approaches and their intellectual bases and that further progress will require that these differences be brought into the open. There is a difference central to the design of educational technologies in the so-called knowledge age. The difference is between designs for constructive work around available knowledge versus constructive work aimed at generating new knowledge. This distinction of old knowledge versus new knowledge is elaborated below in light of knowledge age challenges for education.

The ability of a society to generate new knowledge is coming to be seen as a major determinant of the health and wealth of nations (Romer 1993) and education as the foundation of that ability (Drucker 1994). "Knowledge-building" is the term used to focus on the new knowledge challenge. Two key points: Most educational technology, including modern constructivist technology, does not address the new knowledge challenges but instead reproduces approaches adapted to the acquisition of old knowledge; and environments designed for the creation and improvement of new knowledge—knowledge-building environments—are better suited to the new knowledge challenge.

The adage "there's nothing new under the sun" reflects the fact that it is difficult to pinpoint the time when an idea first enters our culture; nonetheless, some ideas clearly entered before others, and many can be dated, if only approximately. The distinction between extant and new knowledge is becoming increasingly important to knowledge age considerations. The distinction between learning and knowledge-building captures this important difference. Learning is a process through which a person's beliefs, attitudes, or skills change and grow. It encompasses all those

means by which our cultural heritage is passed from one generation to the next. Knowledge-building, by contrast, involves the creation of new knowledge.

Throughout most of history, learning constituted an adequate objective for education, because knowledge was not thought of as advancing; it was thought to be in greater danger of deteriorating or getting lost. Perhaps not until the curriculum reforms of the 1950s did the idea become firmly established that knowledge is continually advancing and that the schools accordingly have a responsibility to keep students abreast of it. The knowledge age adds a new requirement: Students must learn how to contribute to the production of new knowledge. This is a radically different challenge for education—different from both the ancient challenge of cultural transmission and the more recent challenge of lifelong learning.

Knowledge-building that makes headlines produces ideas that are new to the world. However, authentic knowledge-building can also occur through the production of ideas that are new to the participating community. Much of the work of scientists, for instance, is devoted to *reconstructing* the work of their colleagues (Dunbar 1995). This reconstructed work then becomes community knowledge—a form of new information and shared intellectual property that other community members can all build on. This challenge of creating community knowledge and continually improving it is what distinguishes knowledge-building classrooms from classrooms in which learning (including "constructivist" learning) is the focus. When people set out to create knowledge, they are embarking on a different kind of enterprise from those who set out to learn. That difference is elaborated below, after a brief review of current learning technologies.

Old Learning Technologies and Modern Parallels

Old: one-to-one conversation and tutoring
New: e-mail, telementoring, intelligent tutoring systems

One-to-one interaction is regarded as an educational ideal. Efforts to realize this ideal through information technology have included intelligent tutoring systems and telementoring. Intelligent tutoring systems, like human tutors, are expected to respond flexibly to student inputs so as to optimize progress toward a learning objective. Telementoring involves one-to-one interchanges between tutor and student, as well. It typically relies on e-mail exchanges between an individual student and someone more expert in the domain (Neils 1997). Its success is highly dependent on the match between mentor and student, and it is difficult for benefits to spread beyond the dyad. Common to both old and new one-to-one approaches is their typically asymmetric character. The tutor or mentor, whether human or machine, is in charge and directs the learning process. The tutor attempts to

understand or diagnose the learner's processes, but the learner is not afforded insight into the tutor's thinking. Within a KBE, by contrast, tutors and mentors join the community as expert learners, exploring ideas at the growing edge of their understanding. All members engage in self- and group assessment, with mentors extending their own knowledge and modeling the process rather than simply assuming diagnose-and-answer roles.

Old: small-group discussion
New: threaded discourse, online forums, bulletin boards

Small-group work has been the principal way of breaking the pattern in which all communication is mediated through the teacher. Substantial responsibility is transferred to students, and interactions can be quite productive. However, it often proves unmanageable unless the groups have definite and limited tasks; but this reduces the responsibility assumed by the students. Without a facilitator, there is a tendency for discussions to be dominated by outspoken students. Knowledge generated in small groups tends to be ephemeral, with no recording of it and no teacher to serve as the corporate memory; and what is produced in one group is not readily available to others. Threaded discourse, now a standard adjunct to course delivery systems, mirrors small-group discussion. Problems with threaded discourse parallel those of small-group discussions, with fewer of the advantages. The first entries set the discourse, with subsequent entries moving farther from the initiating goal, seldom establishing a higher-level goal than the first entry. And threads encapsulate ideas, eliminating potential cross-thread synergies. Revision is typically not permitted (to preserve the discourse in its original form), but this encourages a rambling discourse. The strict downward-branching format of threaded discourse discourages rising above to some more integrated framework. Participants typically have only two options—to branch downward from an existing entry, or to start a new thread. In KBEs, by contrast, conversations can move not only downward but also upward to a higher level of integration and horizontally to create connections across different threads and discourses.

Old: large-group lectures
New: broadcast media, online lectures, listservs

New media for large-group interactions actually reinforce rather than diminish centralized control, in that they increase the separation between the teacher in charge and the learners. Much of the popularity of these media arises, of course, from the fact that they do not fundamentally alter the character of educational discourse and therefore require no basic change. This is signaled by the common expression of "putting a course online"—implying, as is often the case, that it simply involves importing old material into a new medium. By contrast, KBEs provide a forum

through which teachers and learners share responsibility for knowledge advancement.

Old: conferences
New: teleconferences; telepresence; streaming video
Computer-mediated conferences and video-enhanced meetings aim to reproduce the characteristics of small- or large-group face-to-face interactions. For geographically separated participants, this provides opportunities for a more personal level of social interaction and sharing. This can be valuable, particularly at the beginning and at critical junctures in collaboration. The term "telepresence" refers to the ideal of imbuing an online conference with all the experiential qualities of a face-to-face discussion. From an educational standpoint it also embodies the familiar limitations of the group and classroom discussions that it aims to reproduce. KBEs create more flexible and decentralized spaces for collaborative interactions.

Old: research project
New: computer-mediated projects
The school research project is a staple of education, seldom involving original research and instead drawing on available reference material. It is known in the educational literature for reinforcing a pernicious educational strategy called "copy-delete," whereby researchers copy material from reference resources and delete irrelevant information (Brown and Day 1983). The result is a collage of copied material, reworded to avoid plagiarism. The Internet makes this knowledge replication strategy increasingly easy. At its worst, computer-mediated project-based work consists of similar cut-and-paste media projects; in others, students' contributions are limited to filling in the blanks of electronic templates. Often the discourse is the weakest part of collaborative projects, focusing on concrete details of getting the job done and determining who will do what rather than advancing ideas. Within a KBE project work is more easily transformed into authentic knowledge-building. Participants contribute artifacts to a public forum, with the expectation that these artifacts will enhance the knowledge resources of the whole community and be continually refined by that extended community.

Old: field trips, laboratory exercises
New: simulations and microworlds
The field trip is the classic way to explore worlds that are not easily represented through school-based instructional materials. New knowledge media extend the range of experiences and concepts that can be brought into school, through video productions, simulations, and microworlds. Physics

microworlds, for example, allow students to explore concepts such as force and momentum by applying "kicks" to objects under different conditions and testing results (see, e.g., White 1993). In well-engineered environments, explorations are designed to maximize opportunities for discovering the deep principles of the domain. Video productions can anchor instruction in real-world phenomena (e.g., the Jasper Woodbury series). Although computer-based explorations lack the immediacy and the "embodied cognition" of real-life exploration, they afford greatly enhanced opportunities for experimental probing and testing of conjectures. In order for these to coalesce into theoretical understanding, however, a more comprehensive constructive process has to take place. Over the years designers of anchored instruction and simulations have added prompting, discussion tools, and cooperative groups to their environments (White and Frederiksen 1998; Linn and Hsi 2000; Cognition and Technology Group at Vanderbilt 1997) in an effort to achieve greater depth and integration. The same problems of superficial and piecemeal learning occur, of course, with respect to real-life experiments and field trips. KBEs provide a means for learners to record their ideas as they explore these phenomena. Their ideas live alongside the simulation that is actually incorporated into the KBE, where it serves as a tool in a larger effort to advance knowledge.

The main thrust of current learning technologies has been to reproduce time-honored educational mechanisms, sometimes with improvements. "Constructivism" in this context refers to the extent of active versus passive involvement of students in the learning process. It does not refer to knowledge creation, as carried out in modern professions, the sciences, research enterprises, and innovation-driven companies. Supporting that kind of process is a challenge being addressed in the design of knowledgeware, and knowledge management literature, but it represents a new and unfamiliar challenge for educational technology—a challenge to be addressed through KBEs (Scardamalia and Bereiter, forthcoming).

New Technologies for New Knowledge

Knowledge-creating organizations generate community knowledge and continually improve it. KBEs support this process and extend the possibilities. Participants contribute ideas to community knowledge spaces, where these ideas are advanced through interactions with others. Contributed ideas become objects for continual testing, improvement, and linking to other ideas. As ideas develop, problems are reformulated at more complex levels, new information is contributed, the amount of knowledge that is presupposed increases, standards rise, and participants are challenged to create increasingly coherent wholes based on the diverse ideas contributed.

Continual idea improvement requires knowledge-building discourse. This discourse contrasts with threaded discussion. Threaded discussion typically

follows the question-and-answer or opinion-and-response formats, both of which are more conducive to the acceptance or rejection of ideas than to idea improvement. As illustrated by the CSILE/Knowledge Forum®, a true KBE affords much more constructive work with ideas than does a simple threaded discussion environment: All entries can be built on directly or embedded in other notes, with automatic citation and links back to the original note; ideas are fortuitously brought into new discourses and new contexts through searches and collective design spaces that allow for new conceptual structures. More generally, ideas are kept alive through a variety of functions, and there is always the option, in any discourse, to move to a higher level of integration or to create connections across different discourses.

If we revisit the idea of telementoring, we gain a better idea of the advantages of having all participants creating and being responsible for community knowledge. To review briefly, telementoring matches a mentor/teacher with a learner, typically engaged in e-mail exchanges. Contrast this with telementors in the Knowledge Forum. The mentors are brought into the public, community forum in which the students are working. Even if the input is directed to a particular person, it is accessible to all community members. The mentor's advice is then read by a broader audience; the mentors themselves read each other's exchanges. Not only is advice more broadly received; mentors learn to become better mentors (O'Neill and Scardamalia 2000). Expertise is broadly distributed rather than residing in one-to-one interactions.

KBEs similarly alter the framework for project-based learning. Project participants contribute their work (plans, project responsibilities, summary of research findings, notes, multimedia productions, original texts, Internet resources, etc.) into a public forum. The evolution of the project—not just its endpoint—is available to all. And after a project is complete, the solutions and artifacts, and the discussions that surround them, remain available for extended work. In a KBE, "production values" are important, but idea advancement is more important. The project is not an encapsulated activity whose endpoint is a presentation: Rise-above dynamics support higher-level productions, with the output from one project serving as input to new, more advanced efforts. Database access and linking structures favor flexible, opportunistic meetings of participants, with discourses linked through one large discourse or a set of interlocking discourses, as users wish. This contrasts with the often highly regimented projects designed by others, with students in the implementation role rather than engaged in design as well.

From Learning Technologies to Knowledge-Building Environments

As already noted, discussion is increasingly being added as a layer on top of other kinds of learning technology such as simulations and mi-

croworlds. This is a worthwhile enhancement, consistent with time-honored principles of good teaching, although there are indications that this added layer of work is often treated in a perfunctory manner by students (Guzdial 1997). A KBE may well incorporate or link to simulations, microworlds, and other applications relevant to work with ideas, but outputs from these applications are brought into the shared workspace, where they serve as objects of discourse to help advance the overall knowledge-building effort. Knowledge-building discourse drives the work rather than being an adjunct to it. The potential of KBEs for learning applications is suggested by experiments in which student work in a physics simulation or Jasper Woodbury problem is carried out within CSILE/Knowledge Forum, resulting in advanced problem-solving (Scardamalia, Bereiter, and Lamon 1994).

The largest body of data available from the use of KBEs comes from the CSILE/Knowledge Forum initiative. Positive results are consistently found in contexts where the social innovation—knowledge-building communities—is combined with the technological innovation—CSILE/Knowledge Forum. When the social practices of the classroom remain tied to traditional teaching-learning models, the changes are not as impressive. When knowledge-building communities and KBEs combine to produce self-organizing systems for creating new knowledge, results indicate significant advances in textual, graphical, and computer literacy, as well as in depth of inquiry, collaboration, and a host of mature knowledge processes (Scardamalia, Bereiter, and Lamon 1994). Such results suggest that it is helpful to distinguish learning from knowledge-building and that technology designed to support the distinctive social and cognitive dynamics of knowledge can make a valuable contribution to education.

Marlene Scardamalia

See also Computer-Mediated Communication; Constructivism; CSILE/Knowledge Forum; Educational Systems Design; Jasper Woodbury; Research on Media and Learning; Telementoring

References

Brown, Ann L., and Jeanne D. Day. 1983. "Macrorules for Summarizing Texts: The Development of Expertise." *Journal of Verbal Learning and Verbal Behavior* 22: 1–14.

Cognition and Technology Group at Vanderbilt. 1997. *The Jasper Project: Lessons in Curriculum, Instruction, Assessment, and Professional Development.* Mahwah, NJ: Lawrence Erlbaum Associates.

Drucker, Peter F. 1994. "The Age of Social Transformation." *Atlantic Monthly* 274(5): 53–80.

Dunbar, Kevin N. 1995. "How Scientists Really Reason: Scientific Reasoning in Real-World Laboratories." In R. J. Sternberg and J. Davidson (eds.), *Mechanisms of Insight* (pp. 365–395). Cambridge, MA: MIT Press.

Guzdial, Mark. 1997. "Information Ecology of Collaborations in Educational Settings: Influence of Tool." In Rogers P. Hall, Naomi Miyake, and Noel Enyedy (eds.), *CSCL '97* (pp. 83–90). Toronto: Computer Supported Collaborative Learning.

Linn, Marcia C., and Sherry Hsi. 2000. *Computers, Teachers, and Peers: Science Learning Partners.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Neils, David. 1997. "Research on the HP E-Mail Mentor Program—School Contact Status Report." *HP Telementoring News:* 1–3.

O'Neill, Kevin, and Marlene Scardamalia. 2000. "Mentoring in the Open: A Strategy for Supporting Human Development in the Knowledge Society." In Barry Fishman and Sam O'Connor-Divelbiss (eds.), *Proceedings of the Fourth International Conference of the Learning Sciences* (pp. 326–333). Mahwah, NJ: Lawrence Erlbaum.

Romer, Paul. 1993. "Two Strategies for Economic Development: Using Ideas and Producing Ideas." In *Proceedings of the World Bank Annual Conference on Development Economics.* Washington, DC: World Bank.

Scardamalia, Marlene, and Carl Bereiter. Forthcoming. "Knowledge Building Environments: Extending the Limits of the Possible in Education and Knowledge Work." In *Encyclopedia of Distributed Learning.* Thousand Oaks, CA: Sage.

Scardamalia, Marlene, Carl Bereiter, and Mary Lamon. 1994. "The CSILE Project: Trying to Bring the Classroom into World 3." In Kate McGilly (ed.), *Classroom Lessons: Integrating Cognitive Theory and Classroom Practice* (pp. 201–228). Cambridge, MA: MIT Press.

White, Barbara Y. 1993. "ThinkerTools: Causal Models, Conceptual Change, and Science Education." *Cognition and Instruction* 10(1): 1–100.

White, Barbara Y., and John Frederiksen. 1998. "Inquiry, Modeling, and Metacognition: Making Science Accessible to All Students." *Cognition and Instruction* 16(1): 1–100