Beyond Information Pumping: Creating a Constructivist E-Learning Environment

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Introduction

E-Learning is currently one of the "biggest" things in the world of training and learning. The popularity of e-Learning stems from its advantages, such as 24/7 accessibility, anytime-anywhere learning, ease of update of information, and self-paced learning. Very often, information is presented as hypertext, sometimes including hypermedia. The notion of re-usable learning objects is also gaining popularity. In this article, it is argued that simply presenting information to learners may not be the best way for e-Learning to occur, as it is making too many assumptions: the learners are motivated, the learners are able to learn independently, and the learners can transfer and apply the knowledge to real-life situations. It is proposed that to best harness the potential of Internet affordances, the definitive advantage of e-learning over learning via other media is to adopt a social constructivist approach, which is based on Vygotskian theories of learning and situated cognition.

The e-Learning Hype

If you have ever observed a group of small kids talking about the latest toy in the market, you will be amazed by the intense emotion embedded in their highly gestured conversation. It is as if the new toy is the only thing that matters in the world, and possessing it would bring them the ultimate honor in their circle of friends. E-Learning to trainers and educators is likened to the new toy (for the kids). It now seems that everybody that has something to do with training or education, whether in the corporate sectors or in educational institutions, seems to be talking about e-Learning. Many cannot wait to jump on the bandwagon to have a share of the e-learning pie, if we may mix metaphors.

But what is e-Learning? One can find dozens of definitions in magazines, periodicals, or online journals. According to the e-Learning glossary in *Learning Circuit* (ASTD, 2001), e-Learning "covers a wide set of applications and processes, such as Web-based learning, computer-based learning, virtual classrooms, and digital collaboration. It includes the delivery of content via Internet, intranet/extranet (LAN/WAN), audio- and videotape, satellite broadcast, interactive TV, and CD-ROM." In the book *Leading E-Learning* (Horton, 2001), it is defined as the "use of Internet and digital technologies to create experiences that educate our fellow human beings."

There seems to be some confusion about the definitions, but if one were to analyze it closely, there is convergence among these definitions. In the broadest sense, e-Learning is learning administered via any electronic medium—CD-ROM, video, or Internet. In practice, the dominance of Internet technology makes it the medium of choice among the electronic media.

Why is e-Learning creating such a storm? If one were to search for a reason for using e-Learning, it is not hard to find the following reasons being cited:

1. **24/7 Accessibility**
   E-Learning makes anytime, anywhere learning possible. Users can access information 24/7 (24 hours a day, 7 days a week). Most forms of media rely on physical carriers of information (e.g., books or CD-ROM), which can be used by one or a small group of users at a time. Information access via the Internet can be done anywhere and by many users as long as the users have access to the network. With the advent of technology like wireless ports, PDAs and such, anytime, anywhere accessibility becomes a reality.
2. **Ease of Update**
   For other media, such as books or CD-ROMs, to update information, one needs to make a printed document or press a CD-ROM, then distribute these media to the users. Internet connection makes possible updating of materials from the comfort of one's home, and removes the hassle of physically distributing the media.
3. **Hypermedia Delivery**
   Unlike text print in a book, which flows in a linear fashion, the WWW is a hypermedia system in which hyperlinks are used to allow more meaningful access to information based on

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related ideas. The hypermedia feature, however, is also possible in other computer-based media.

4. **Self-Paced or Self-Directed Learning**
   Unlike a classroom situation in which the instructor decides the pace of learning and instructional sequence, e-Learning allows users to learn at their own pace and in their own sequence. This is partly afforded by the hypermedia capability of the WWW.
5. **Communication and Collaboration Tools**
   The Internet opens up channels of conversation and expertise beyond physical and regional boundaries. Learners, with different levels of expertise and distributed among various geographical locations in the world, are able to learn together beyond the boundaries of classrooms.

It is for these reasons that a lot of effort has been channeled toward managing information the "e" way. To illustrate how a typical learning management system operates, imagine Alex, a university student, learning from an e-learning course. Alex first logs on to the system and is greeted by a list of courses for which he has signed up. Upon selection of a course from the list, he is brought to a page with an arrangement of icons or buttons, and probably some announcement. He can now access various course materials by clicking on these icons or buttons. Some common materials include course schedule, course information, course materials and documents, a discussion forum, assignments, online assessment, online chat, and reference links. The course materials can range from text documents to interactive tutorials. Upon completing the course content, Alex can choose to do the online assessment and obtain immediate results on his performance.

What's Wrong with Information Pumping?

Such an approach to instruction places great emphasis on facilitating learning management. Learning management may enhance the efficiency of learning; however, its effectiveness in enhancing learning is based on a few assumptions. First, the learner is assumed to be capable of self-directed learning. The learner is assumed to be able to process the information by reading the text, hypertext, or hypermedia; to search for relevant information to fill his knowledge gaps; to monitor his own understanding before taking the big test; and to confidently complete this process without personal guidance. Second, it is assumed that the learner is motivated to learn about the topic being presented. Very often, the major source of motivation is the assessment. The learner processes the information meticulously as he or she strives to achieve a better grade. Third, transfer of learning occurs naturally where the learner is able to apply what he or she has learned in a real-world context.

These assumptions may be valid for adult learners who initiate learning triggered by problems faced in the workplace. Suppose Alex has recently graduated from the university and has taken on the job of a new project manager. For him, learning about project management is imperative. Because of the demand of his job, while going through the course material, he will naturally interpret the course content in terms of his workplace context and experience. Getting a good grade in the course is relatively less important, but solving real-life problems naturally motivates him to assimilate and apply the knowledge learned.

This model, however, may break down for learners who are learning out of real-life context(s), particularly those in educational institutions. The first assumption, that of a self-directed learner, is relatively easy to solve. If a learner is lacking in self-directedness, an e-moderator or e-facilitator may provide assistance. An interactive tutorial may also help to enhance acquisition of knowledge. However, a lot more has to be done to motivate learners and to ensure transfer of learning.

In addition, although content is also easily accessible because of the Internet, we believe the effectiveness of learning is enhanced if we capitalize on the unique affordances of the Internet technology—communication and collaboration. Affordances refer to the fit between human capabilities and external objects, such as environmental supports and opportunities that make possible a given activity (Gibson, 1979; Gibson & Pick, 2000). The Internet is an ideal communication medium, which connects distributed expertise and facilitates collaboration. This feature best supports social constructivist learning, the central tenet of which is learning through social interaction and co-construction of knowledge. In other words, the assumption we have made here is that the process of learning is facilitated through *construction* rather than *information pumping.*

Understanding Constructivist Learning

Let us start by looking at some of the theoretical underpinnings of constructivist learning. The following theoretical works and positions shape the current notion of constructivism:

Constructivist learning, as advocated by Piaget (1960,1981) and Bruner (1990), posits that meaning is constructed in the mind of individuals through discovery, with a focus on the process of assimilation and accommodation of knowledge. Meaning is perceived as inseparable from one's own interpretation. Its emphasis is not in the interactions of the individual with the environment (including other social beings) but more on how the mind constructs knowledge. Learning is an active process of constructing rather than acquiring knowledge. Knowledge is not just a mental state; rather, "it is an experienced relation of things, and it has no meaning outside of such relations" (Dewey, 1910/1981, p. 185).

More recently, the social orientations of constructivism commonly linked to Vygotsky (1978) and neo-Marxist theories of practice (e.g., Lave & Wenger, 1991) have gained wide currency. Vygotsky emphasizes the cultural influences and social context influencing learning. Vygotskian constructivism is called social constructivism because he emphasized the critical importance of interaction with people in cognitive development. Where Piagetian constructivism emphasizes cognition as an individual activity and 'in the head,' social constructivism focuses mostly on knowledge socially constructed 'in the world.'

Vygotsky's (1978) *Zone of Proximal Development* (ZPD) emphasizes his belief that learning is fundamentally a socially mediated activity. Thinking and problem solving can be placed in three categories. Some can be performed independently by the child. Others can be performed even without help. Between these two extremes are the tasks the child can perform with the help of others. These tasks fall within the ZPD. If the child uses these cognitive processes with the help of others, such as teachers, parents, and other students, they will gain skills and abilities that can be used independently later. The fundamental premise of Vygotsky's theory is that communicative acts through collaboration can be internalized. Vygotsky sees psychological tools as mediators for cognition that begin at the social level and become internalized at the individual level. In fact, Vygotsky posits that all cognition begins at the social-cultural level through the mediation of human signs and symbols. Language is a crucial 'psychological tool' mediator. If so, dialog through language becomes an important factor for internalization of meanings to take place—and thus learning.

Constructivists emphasize situating learning experiences in a real-world context—rooted in the notion of situated cognition proposed by Brown, Collins, and Duguid (1989). Brown *et al.* (1989) argue that personal experience is crucial to the construction of meaning. An idea, together with an individual's experience with that idea, is an integrated unit that constitutes the meaning of an individual understanding of that idea. Thus, experience with the idea is critical to its understanding and one's ability to use and apply the idea. Following this argument, Resnick (1987) points to the distinct differences between in-school and out-of-school experiences, and argues that decontextualization is the cause of lack of transfer in school learning. Brown, Collins, and Duguid (1989) regard learning as an enculturation process—a social process situated in the practices of a culture. Learning occurs when a person is actively engaging and participating in the practices of a culture in a community.

To summarize, constructivist learning encourages the learner to engage in the active process of meaning-construction in real-authentic problems and situations, and where learners are able to socially construct knowledge with others. Importantly, learning construction can also be facilitated through guidance by more knowledgeable peers or adults, but the responsibility and ownership for learning must be on the learner.

The above are some salient theories and perspectives that lay the foundation for many current proponents of constructivist learning. In the next section, two constructivist learning frameworks or models will be reviewed.

Constructivist Models

Perkins' Five-Facet Learning Environment

Perkins (1992) proposes a five-facet constructivist learning environment that aims at achieving the educational goals of 'retention, understanding, and active use of knowledge and skills':

1. *Information Banks.* The information bank by Perkins is our familiar information resources mentioned in the earlier section of this article. According to Perkins, it is the 'source of explicit information about topics,' and they include 'dictionaries and encyclopedia' and 'the teacher.'
2. *Symbol Pads.* The symbol pads refer to 'surfaces' that allow learners to construct and manipulate symbols. They include simple tools like a notepad to a sophisticated laptop computer.
3. *Construction Kits.* Construction kits, according to Perkins, are tools that allow the learners to manipulate and construct objects. They range from Legos, to chemical apparatus, to computer programming languages. Perkins acknowledges the similarity between construction kits and symbol pads, but emphasizes that construction kits possess prefabricated parts and processes, and thus impose certain structure during the construction of the objects.
4. *Phenomenaria.* Phenomenaria, a term coined by Perkins, refers to 'an area for the specific purpose of presenting phenomena and making them accessible to scrutiny and manipulation.' It includes laboratory chemical problems, microworlds, and simulation games.
5. *Task Managers.* Task managers set learning activities or tasks for learners, provide guidance and assistance, and offer feedback and assessment. A typical task manager is the teacher, but task managing could also include activity templates, learners, and even computers.

Perkins's model is generic to all learning environments, as he further argues that not all learning environments display all the five facets. A more traditional didactic classroom instruction would include the teacher and text as the sources of the information banks, symbol pads like notebooks or worksheets, and the teacher as the task manager. A more constructivist learning environment, on the other hand, will place phenomenaria and construction kits at its heart. One such example is the Logo construction language by Seymour Papert (1980).

Building on the work of Piaget and Bruner, Perkins further proposes two approaches of constructivism: BIG (Beyond the Information Given) and WIG (Without the Information Given) constructivism. The BIG approach stresses providing opportunities for learners to 'work through their understanding in various ways.' This may be achieved through learning activities that provoke in-depth reflection of initial understanding and to apply and generalize the understandings. On the other hand, the WIG approach avoids direct instruction, but advocates learning in which concepts are discovered, at least in part, by the learners.

Jonassen's Constructivist Learning Environment (CLE)

Jonassen (1999) proposes a model for designing constructivist learning environment that aims to engage learners in meaning-making. The model consists of six components and three supporting strategies:

1. **Problem or Project.** At the heart of the model is the question, issue, problem, or project that serves as the focus of the learning episode. Jonassen argues that problems should drive learning, rather than starting with theories or principles and reducing problem solving to an application exercise. Using interesting, engaging, and authentic problems helps promote ownership of the problem and thus motivates the learners towards the learning goal. To achieve that, the problems should arise out of a real-life context, which is usually ill-structured, with some emergent aspects that are definable by the learners. To communicate the problems to the learners, we need to specify the problem context (the environment and community of practitioners), the problem representation, and the problem manipulation space (which provides the objects, signs, and tools for learners to manipulate with some variables in the environment).
2. **Related Cases.** Based on case-based reasoning and cognitive flexibility theories, Jonassen proposes using related cases to supplant student experience—the argument being that human knowledge is encoded as stories about past events and experience. When met with a new situation or problem, human beings tend to search their memories for related cases. In addition, related cases provide multiple representations of content that reflect the complexity of a domain knowledge. Novice learners are usually lacking in experiences in certain problem situations; providing such scaffolding is thus critical.
3. **Information Resources.** Relevant information should be provided so that the learners can understand and solve the problems, with the assumption that information makes most sense in the context of its application. Information banks and repositories should be provided in a just-in-time and learner-selectable way. Jonassen emphasizes the importance of selecting relevant and appropriate materials, including Web-based materials, with embedded hyperlinks to these materials at appropriate juncture.
4. **Cognitive Tools.** Cognitive tools refer to computer tools that engage and facilitate certain cognitive processes. They help to support the learners in performing the problem-solving tasks. Cognitive tools include visualization tools, knowledge-modeling tools, performance-support tools, and information-gathering tools.
5. **Conversation and Collaboration Tools.** Fostering a collaborative learning environment is premised on the notion of social constructivism, which emphasizes learning through collaborative construction of socially shared knowledge. A number of computer-mediated communication tools can be used to support dialog and collaboration within a community of learners, who share similar knowledge and values and are pursuing similar learning goals. Collaborative tools include simple discussion forums to scaffolded environments.
6. **Social/Contextual Support.** The social and contextual support includes readiness in physical infrastructure and training to instructors and learners. This is an important factor necessary for successful implementation of the learning activities.

In addition to the above components, Jonassen suggests three supporting strategies—modeling, coaching, and scaffolding. Modeling includes behavioral modeling of overt performance, such as showing worked examples, as well as cognitive modeling of covert intellectual processes, like articulating reason or decision-making. Coaching focuses on a learner's performance. It involves motivating learners, analyzing their performances for feedback and advice, and provoking reflection. Scaffolding refers to the systemic approach to support the learners, which includes providing frameworks to support performance and adjusting task difficulty.

Design Factors

When we consider the above two models in order to appropriate the design considerations for e-learning, we have the following factors:

- learner(s) acting within the context of a problem (or related problems);
- problems could also be simulated environments or phenomenaria;
- cognitive tools or construction kits in order to engage in the process of solving the problem(s) or task(s);
- information resources or information banks (including case libraries) through which learners can search for knowledge;
- communication tools or conversational tools for collaboration and the co-construction of knowledge; and
- task managers and social context support, either for administrative functions or for mentorship or peer guidance.

Technology in Constructivist e-Learning Environments

To better visualize the above principles as described for constructivist learning in e-Learning, see Figure 1.

Figure 1 illustrates an individual learner working on a problem with the support of cognitive tools, information resources, case libraries, and communication tools (as suggested by Jonassen's Constructivist Learning Environment), as well as the task manager (as suggested by Perkins). All these resources and tools are afforded by e-Learning technology, such as the Internet and a learning management system. The symbol pads can be individual electronic documents, such as Microsoft Word or a shared document that the learner co-works with others. The computer or other electronic devices also function as the link to a larger community (see Figure 2).

Figure 2 shows how each learner unit is connected via networked computers. One of these can be an instructor's unit, from which the instructor will provide modeling, coaching, scaffolding, and facilitation of interactions among learners. The instructor is placed as a peripheral unit because in certain cases, some of the instructor's functions can be performed by the learners. Learners with different expertise can take turns to lead, model, coach, scaffold, and facilitate. For instance, in a Webpage design course, Alex, who has taken a course on Dreamweaver, could help to answer questions about the operation of the software. Marie, Alex's course mate, could have expertise on Java programming and would be able to assist others in this area. The contextual support, like physical infrastructure, must be in place for such interaction to occur. Contextual support may also be exhibited through a supportive organizational culture for e-Learning.

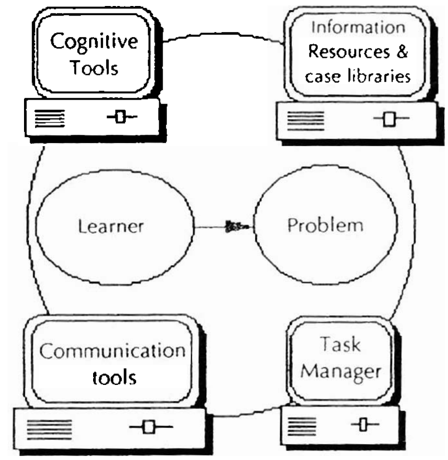

Figure 1. Individual learning supported by technology.

An Example of Constructivist e-Learning: Concrete Clinic

The first author has conceptualized a prototype of a constructivist e-Learning module together with the Department of Civil and Environmental Engineering at Pennsylvania State University. The main objective is to impart in civil engineering undergraduates, the skills in diagnosing and solving problems in the building of physical concrete structures.

The module, titled "Concrete Clinic," includes resource links, case studies, and problem-solving activities. As an example, one problem-solving activity starts with the description of a real-life concrete engineering problem together with photographs to establish the authenticity of the problems (Figure 3).

Next, the learner is prompted to diagnose the problem, followed by justification for the diagnosis. Feedback is given to the learner on the answer and the correct reasons provided (coaching). A learner who is not sure how to proceed with the diagnosis can opt for expert advice (modeling). At any time, the learner can click on the Library button that opens a new Window housing a repository of information on cement and concrete (information resources). After the concrete problem is identified, the learner will be led to the next phase of problem solving: suggesting a plausible solution to the problem. The learner can opt to study a few related cases (case libraries), which help to provide expert experience in problem solving (scaffolding). During the study of related cases, a blank space is provided (symbol pad) for the learner to type in the solution to these cases. Upon submitting the answer, an expert solution will be shown (modeling). The learner

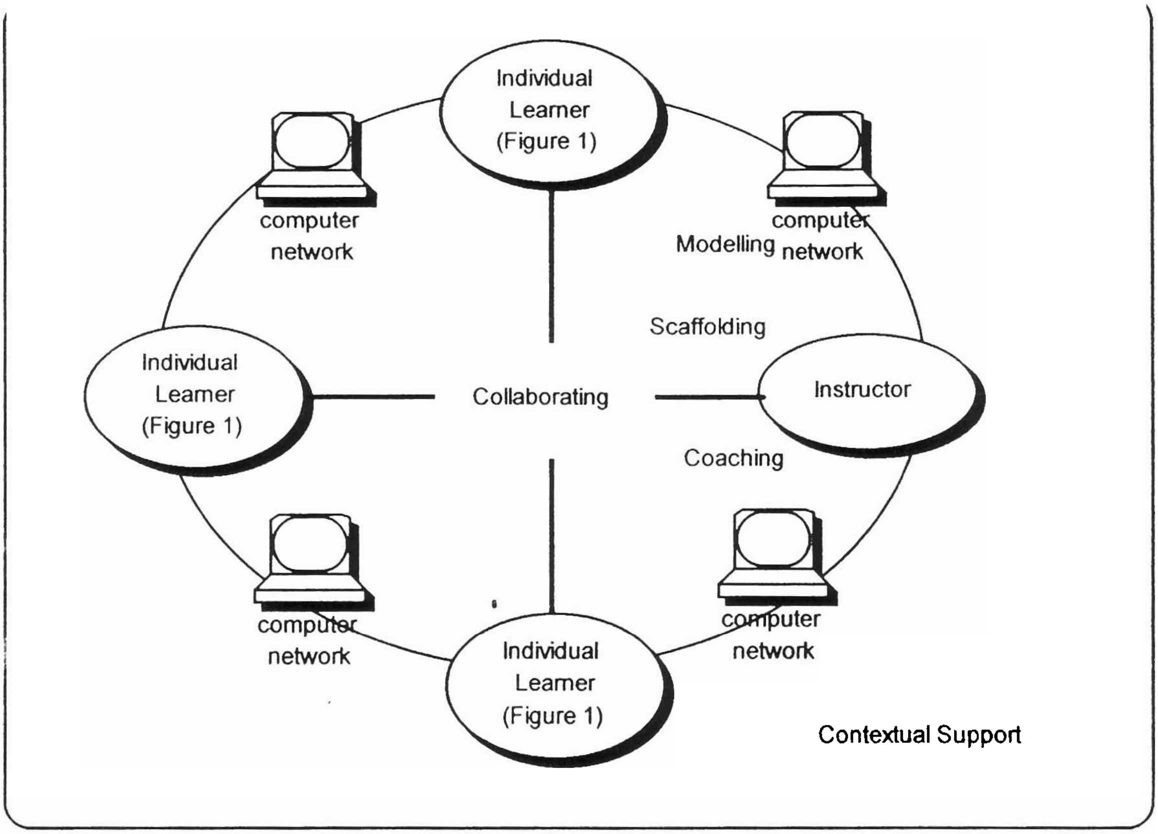

Figure 2. Learning within an e-Learning community.

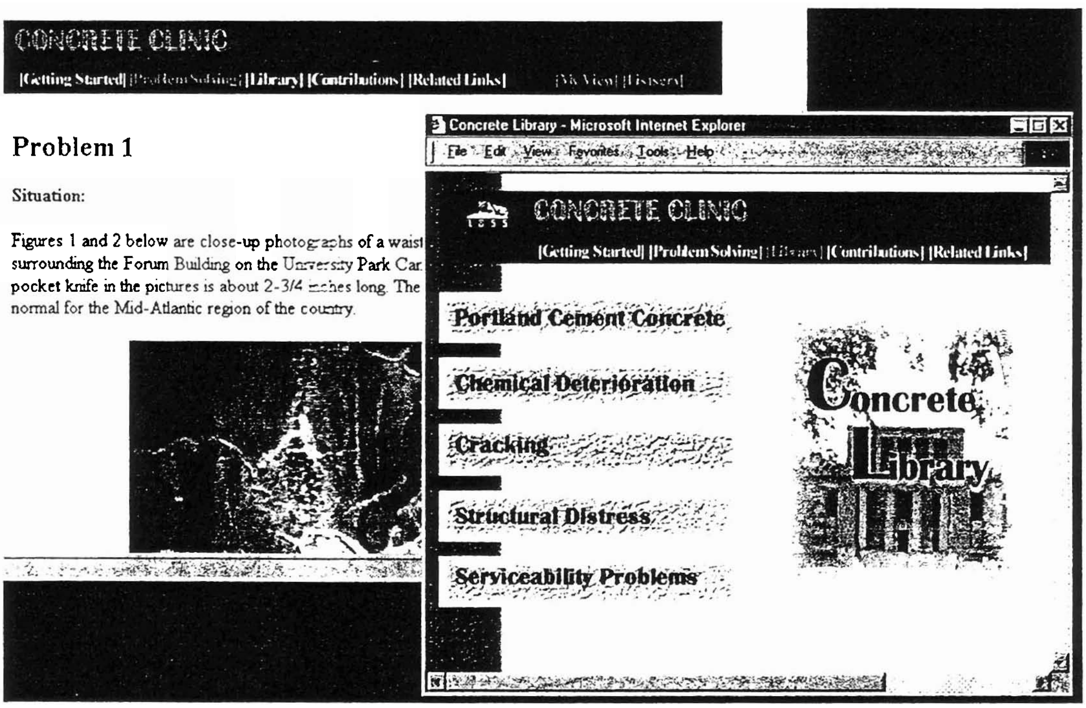

Figure 3. Screen shot of problem presentation and library in the study of concrete.

can then click on a "Final Report" button which activates a template for reporting the final solution (scaffolding). At any time, the learner can participate in a discussion by clicking on the Listserv button to communicate with peers (communication tool). Notice that the learner is guided through the process of problem solving; thus the task manager is built-in to the module.

This prototype module illustrates how the various elements of a constructivist learning environment can be actualized, in a topic (engineering of concrete structure) not ordinarily considered amenable to a constructivist approach.

Conclusion

E-Learning is creating a wave in the education and training industry. Some educators and trainers choose to jump into the stormy sea without any safety device, while others seek refuge in a harbor. We believe that the e-Learning wave can push us forward to our destination, provided that we are guided by strong pedagogical principles. In this article, we dispel the myth that information access is a sufficient condition for learning, as it holds too many assumptions about learners.

Today's thrust in e-Learning seems to be focused on the management perspective of learning rather than the process of learning itself. Management of learning includes providing user accounts, log-on interfaces, and personalization of contents. These issues are important; however, they miss the essence of learning, which is the active construction of knowledge.

We propose that a constructivist e-Learning environment captures the full essence of e-Learning by creating a rich learning environment that provides motivation, engages higher-order thinking, promotes collaborative knowledge building, and enhances transfer of learning. We hope that this article has encouraged designers of e-Learning to focus some of their efforts on these more active learning processes. □

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A Revision of Bloom's Taxonomy: An Overview

THE TAXONOMY OF EDUCATIONAL OBJECTIVES is a framework for classifying statements of what we expect or intend students to learn as a result of instruction. The framework was conceived as a means of facilitating the exchange of test items among faculty at various universities in order to create banks of items, each measuring the same educational objective. Benjamin S. Bloom, then Associate Director of the Board of Examinations of the University of Chicago, initiated the idea, hoping that it would reduce the labor of preparing annual comprehensive examinations. To aid in his effort, he enlisted a group of measurement specialists from across the United States, many of whom repeatedly faced the same problem. This group met about twice a year beginning in 1949 to consider progress, make revisions, and plan the next steps. Their final draft was published in 1956 under the title, *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive Domain* (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956).[1] Hereafter, this is referred to as the original Taxonomy. The revision of this framework, which is the subject of this issue of *Theory Into Practice*, was developed in much the same manner 45 years later (Anderson, Krathwohl, et al., 2001). Hereafter, this is referred to as the revised Taxonomy.[2]

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Bloom saw the original Taxonomy as more than a measurement tool. He believed it could serve as a

- common language about learning goals to facilitate communication across persons, subject matter, and grade levels;
- basis for determining for a particular course or curriculum the specific meaning of broad educational goals, such as those found in the currently prevalent national, state, and local standards;
- means for determining the congruence of educational objectives, activities, and assessments in a unit, course, or curriculum; and
- panorama of the range of educational possibilities against which the limited breadth and depth of any particular educational course or curriculum could be contrasted.

The Original Taxonomy

The original Taxonomy provided carefully developed definitions for each of the six major categories in the cognitive domain. The categories were *Knowledge*, *Comprehension*, *Application*, *Analysis*, *Synthesis*, and *Evaluation*.[3] With the exception of *Application*, each of these was broken into subcategories. The complete structure of the original Taxonomy is shown in Table 1.

The categories were ordered from simple to complex and from concrete to abstract. Further, it was assumed that the original Taxonomy represented a cumulative hierarchy; that is, mastery of

Table 1
Structure of the Original Taxonomy

1.0 Knowledge
- *1.10 Knowledge of specifics*
  - *1.11 Knowledge of terminology*
  - *1.12 Knowledge of specific facts*
- *1.20 Knowledge of ways and means of dealing with specifics*
  - *1.21 Knowledge of conventions*
  - *1.22 Knowledge of trends and sequences*
  - *1.23 Knowledge of classifications and categories*
  - *1.24 Knowledge of criteria*
  - *1.25 Knowledge of methodology*
- *1.30 Knowledge of universals and abstractions in a field*
  - *1.31 Knowledge of principles and generalizations*
  - *1.32 Knowledge of theories and structures*

2.0 Comprehension
- *2.1 Translation*
- *2.2 Interpretation*
- *2.3 Extrapolation*

3.0 Application

4.0 Analysis
- *4.1 Analysis of elements*
- *4.2 Analysis of relationships*
- *4.3 Analysis of organizational principles*

5.0 Synthesis
- *5.1 Production of a unique communication*
- *5.2 Production of a plan, or proposed set of operations*
- *5.3 Derivation of a set of abstract relations*

6.0 Evaluation
- *6.1 Evaluation in terms of internal evidence*
- *6.2 Judgments in terms of external criteria*

each simpler category was prerequisite to mastery of the next more complex one.

At the time it was introduced, the term *taxonomy* was unfamiliar as an education term. Potential users did not understand what it meant, therefore, little attention was given to the original Taxonomy at first. But as readers saw its potential, the framework became widely known and cited, eventually being translated into 22 languages.

One of the most frequent uses of the original Taxonomy has been to classify curricular objectives and test items in order to show the breadth, or lack of breadth, of the objectives and items across the spectrum of categories. Almost always, these analyses have shown a heavy emphasis on objectives requiring only recognition or recall of information, objectives that fall in the *Knowledge* category. But, it is objectives that involve the understanding and use of knowledge, those that would be classified in the categories from *Comprehension* to *Synthesis*, that are usually considered the most important goals of education. Such analyses, therefore, have repeatedly provided a basis for moving curricula and tests toward objectives that would be classified in the more complex categories.

From One Dimension to Two Dimensions

Objectives that describe intended learning outcomes as the result of instruction are usually framed in terms of (a) some subject matter content and (b) a description of what is to be done with or to that content. Thus, statements of objectives typically consist of a noun or noun phrase—the subject matter content—and a verb or verb phrase—the cognitive process(es). Consider, for example, the following objective: The student shall be able to remember the law of supply and demand in economics. "The student shall be able to" (or "The learner will," or some other similar phrase) is common to all objectives since an objective defines what students are expected to learn. Statements of objectives often omit "The student shall be able to" phrase, specifying just the unique part (e.g., "Remember the economics law of supply and demand."). In this form it is clear that the noun phrase is "law of supply and demand" and the verb is "remember."

In the original Taxonomy, the *Knowledge* category embodied both noun and verb aspects. The noun or subject matter aspect was specified in *Knowledge's* extensive subcategories. The verb aspect was included in the definition given to *Knowledge* in that the student was expected to be able to recall or recognize knowledge. This brought unidimensionality to the framework at the cost of a *Knowledge* category that was dual in nature and thus different from the other Taxonomic categories. This anomaly was eliminated in the revised Taxonomy by allowing these two aspects, the noun and verb, to form separate dimensions, the noun providing the basis for the Knowledge dimension and the verb forming the basis for the Cognitive Process dimension.

The Knowledge dimension

Like the original, the knowledge categories of the revised Taxonomy cut across subject matter lines. The new Knowledge dimension, however, contains four instead of three main categories. Three of them include the substance of the subcategories of Knowledge in the original framework. But they were reorganized to use the terminology, and to recognize the distinctions of cognitive psychology that developed since the original framework was devised. A fourth, and new category, ***Metacognitive Knowledge,*** provides a distinction that was not widely recognized at the time the original scheme was developed. ***Metacognitive Knowledge*** involves knowledge about cognition in general as well as awareness of and knowledge about one's own cognition (Pintrich, this issue). It is of increasing significance as researchers continue to demonstrate the importance of students being made aware of their metacognitive activity, and then using this knowledge to appropriately adapt the ways in which they think and operate. The four categories with their subcategories are shown in Table 2.

Table 2
Structure of the Knowledge Dimension of the Revised Taxonomy

A. ***Factual Knowledge*** – The basic elements that students must know to be acquainted with a discipline or solve problems in it.
- **Aa. Knowledge of terminology**
- **Ab. Knowledge of specific details and elements**

B. ***Conceptual Knowledge*** – The interrelationships among the basic elements within a larger structure that enable them to function together.
- **Ba. Knowledge of classifications and categories**
- **Bb. Knowledge of principles and generalizations**
- **Bc. Knowledge of theories, models, and structures**

C. ***Procedural Knowledge*** – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.
- **Ca. Knowledge of subject-specific skills and algorithms**
- **Cb. Knowledge of subject-specific techniques and methods**
- **Cc. Knowledge of criteria for determining when to use appropriate procedures**

D. ***Metacognitive Knowledge*** – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition.
- **Da. Strategic knowledge**
- **Db. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge**
- **Dc. Self-knowledge**

The Cognitive Process dimension

The original number of categories, six, was retained, but with important changes. Three categories were renamed, the order of two was interchanged, and those category names retained were changed to verb form to fit the way they are used in objectives.

The verb aspect of the original *Knowledge* category was kept as the first of the six major categories, but was renamed ***Remember. Comprehension*** was renamed because one criterion for selecting category labels was the use of terms that teachers use in talking about their work. Because *understand* is a commonly used term in objectives, its lack of inclusion was a frequent criticism of the original Taxonomy. Indeed, the original group considered using it, but dropped the idea after further consideration showed that when teachers say they want the student to "really" understand, they mean anything from *Comprehension* to *Synthesis*. But, to the revising authors there seemed to be popular usage in which *understand* was a widespread synonym for comprehending. So, *Comprehension,* the second of the original categories, was renamed ***Understand.***[4]

Application, Analysis, and *Evaluation* were retained, but in their verb forms as ***Apply, Analyze,*** and ***Evaluate.*** *Synthesis* changed places with *Evaluation* and was renamed ***Create***. All the original subcategories were replaced with gerunds, and called "cognitive processes." With these changes, the categories and subcategories—cognitive processes—of the Cognitive Process dimension are shown in Table 3.

Whereas the six major categories were given far more attention than the subcategories in the original Taxonomy, in the revision, the 19 specific cognitive processes within the six cognitive process categories receive the major emphasis. Indeed, the nature of the revision's six major categories emerges most clearly from the descriptions given the specific cognitive processes. Together, these processes characterize each category's breadth and depth.

Like the original Taxonomy, the revision is a hierarchy in the sense that the six major categories of the Cognitive Process dimension are believed to differ in their complexity, with *remember* being less complex than *understand,* which is less complex than *apply,* and so on. However, because the revision gives much greater weight to teacher usage, the requirement of a strict hierarchy has been relaxed to allow the categories to overlap one another. This is most clearly illustrated in the case of the category ***Understand***. Because its scope has been considerably broadened over *Comprehend* in the original framework, some cognitive processes associated with ***Understand*** (e.g., ***Explaining***) are more cognitively complex than at least one of the cognitive processes associated with ***Apply*** (e.g., ***Executing***). If, however, one were to locate the "center point" of each of the six major categories on a scale of judged complexity, they would likely form a scale from simple to complex. In this sense, the Cognitive Process dimension is a hierarchy, and probably one that would be supported as well as was the original Taxonomy in terms of empirical evidence (see Anderson, Krathwohl, et al., 2001, chap. 16).

The Taxonomy Table

In the revised Taxonomy, the fact that any objective would be represented in two dimensions immediately suggested the possibility of constructing a two-dimensional table, which we termed the Taxonomy Table. The Knowledge dimension would form the vertical axis of the table, whereas the Cognitive Process dimension would form the horizontal axis. The intersections of the knowledge and cognitive process categories would form the cells. Consequently, any objective could be classified in the Taxonomy Table in one or more cells that correspond with the intersection of the column(s) appropriate for categorizing the verb(s) and the row(s) appropriate for categorizing the noun(s) or noun phrase(s). To see how this placement of objectives is accomplished, consider the following example adapted from the State of Minnesota's Language Arts Standards for Grade 12:

> A student shall demonstrate the ability to write using grammar, language mechanics, and other conventions of standard written English for a variety of academic purposes and situations by writing original compositions that analyze patterns and relationships of ideas, topics, or themes. (State of Minnesota, 1998)

Table 3
Structure of the Cognitive Process Dimension of the Revised Taxonomy

1.0 Remember – Retrieving relevant knowledge from long-term memory.
- ***1.1 Recognizing***
- ***1.2 Recalling***

2.0 Understand – Determining the meaning of instructional messages, including oral, written, and graphic communication.
- ***2.1 Interpreting***
- ***2.2 Exemplifying***
- ***2.3 Classifying***
- ***2.4 Summarizing***
- ***2.5 Inferring***
- ***2.6 Comparing***
- ***2.7 Explaining***

3.0 Apply – Carrying out or using a procedure in a given situation.
- ***3.1 Executing***
- ***3.2 Implementing***

4.0 Analyze – Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose.
- ***4.1 Differentiating***
- ***4.2 Organizing***
- ***4.3 Attributing***

5.0 Evaluate – Making judgments based on criteria and standards.
- ***5.1 Checking***
- ***5.2 Critiquing***

6.0 Create – Putting elements together to form a novel, coherent whole or make an original product.
- ***6.1 Generating***
- ***6.2 Planning***
- ***6.3 Producing***

We begin by simplifying the standard (i.e., objective) by ignoring certain parts, particularly restrictions such as "using grammar, language mechanics, and other conventions of standard written English for a variety of academic purposes and situations." (Some of these specify scoring dimensions that, if not done correctly, would cause the student's composition to be given a lower grade.) Omitting these restrictions leaves us with the following:

Write original compositions that analyze patterns and relationships of ideas, topics, or themes.

Placement of the objective along the Knowledge dimension requires a consideration of the noun phrase "patterns and relationships of ideas, topics, or themes." "Patterns and relationships" are associated with ***B. Conceptual Knowledge.*** So we would classify the noun component as an example of ***B. Conceptual Knowledge.*** Concerning the placement of the objective along the Cognitive Process dimension, we note there are two verbs: write and analyze. Writing compositions calls for ***Producing***, and, as such, would be classified as an example of ***6. Create.*** Analyze, of course, would be ***4. Analyze.*** Since both categories of cognitive processes are likely to be involved (with students being expected to analyze before they create), we would place this objective in two cells of the Taxonomy Table: B4, Analyze Conceptual Knowledge, and B6, Create [based on] Conceptual Knowledge (see Figure 1). We use the bracketed [based on] to indicate that the creation itself isn't conceptual knowledge; rather, the creation is primarily based on, in this case, conceptual knowledge.

By using the Taxonomy Table, an analysis of the objectives of a unit or course provides, among other things, an indication of the extent to which more complex kinds of knowledge and cognitive processes are involved. Since objectives from ***Understand*** through ***Create*** are usually considered the most important outcomes of education, their inclusion, or lack of it, is readily apparent from the Taxonomy Table. Consider this example from one of the vignettes in the revised Taxonomy volume in which a teacher, Ms. Gwendolyn Airasian, describes a classroom unit in which she integrates Pre-Revolutionary War colonial history with a persuasive writing assignment. Ms. Airasian lists four specific objectives. She wants her students to:

1. Remember the specific parts of the Parliamentary Acts (e.g., the Sugar, Stamp, and Townshend Acts);
2. Explain the consequences of the Parliamentary Acts for different colonial groups;
3. Choose a colonial character or group and write a persuasive editorial stating his/her/its position on the Acts (the editorial must include at least one supporting reason not specifically taught or covered in the class); and
4. Self- and peer edit the editorial.

Categorizing the first objective, ***1. Remember*** is clearly the cognitive process, and "specific parts of the Parliamentary Acts" is ***Ab. Knowledge of specific details or elements,*** a subcategory of ***A. Factual Knowledge.*** So this objective is placed in cell A1.[5] "Explain," the verb in the second objective, is the seventh cognitive process, ***2.7 Explaining,***

The Cognitive Process Dimension

The Knowledge Dimension	1. ***Remember***	2. ***Understand***	3. ***Apply***	4. ***Analyze***	5. ***Evaluate***	6. ***Create***
A. ***Factual Knowledge***						
B. ***Conceptual Knowledge***				X		X
C. ***Procedural Knowledge***						
D. ***Metacognitive Knowledge***						

Figure 1. The placement in the Taxonomy Table of the State of Minnesota's Language Arts Standard for Grade 12.

under *2. Understand*. Since the student is asked to explain the "consequences of the Parliamentary Acts," one can infer that "consequences" refers to generalized statements about the Acts' aftereffects and is closest to ***Bc. Knowledge of theories, models, and structures***. The type of knowledge, then, would be ***B. Conceptual Knowledge***. This objective would be classified in cell B2.

The key verb in the third objective is "write." Like the classification of the State of Minnesota's standard discussed above, writing is ***6.3 Producing***, a process within ***6. Create***. To describe "his/her/its position on the Acts" would require some combination of ***A. Factual Knowledge*** and ***B. Conceptual Knowledge***, so this objective would be classified in two cells: A6 and B6. Finally, the fourth objective involves the verbs "self-edit" and "peer edit." Editing is a type of evaluation, so the process involved is *5. Evaluate*. The process of evaluation will involve criteria, which are classified as ***B. Conceptual Knowledge***, so the fourth objective would fall in cell B5. The completed Taxonomy Table for this unit's objectives is shown in Figure 2.

From the table, one can quickly visually determine the extent to which the more complex categories are represented. Ms. Airasian's unit is quite good in this respect. Only one objective deals with the ***Remember*** category; the others involve cognitive processes that are generally recognized as the more important and long-lasting fruits of education—the more complex ones.

In addition to showing what was included, the Taxonomy Table also suggests what might have been but wasn't. Thus, in Figure 2, the two blank bottom rows raise questions about whether there might have been procedural or metacognitive knowledge objectives that could have been included. For example, are there procedures to follow in editing that the teacher could explicitly teach the students? Alternatively, is knowledge of the kinds of errors common in one's own writing and preferred ways of correcting them an important metacognitive outcome of self-editing that could have been emphasized? The panorama of possibilities presented by the Taxonomy Table causes one to look at blank areas and reflect on missed teaching opportunities.

The Taxonomy Table can also be used to classify the instructional and learning activities used to achieve the objectives, as well as the assessments employed to determine how well the objectives were mastered by the students. The use of the Taxonomy Table for these purposes is described and illustrated in the six vignettes contained in the revised Taxonomy volume (Anderson, Krathwohl, et al., 2001, chaps. 8-13). In the last two articles of this issue, Airasian discusses assessment in greater detail, and Anderson describes and illustrates alignment.

The Cognitive Process Dimension

The Knowledge Dimension	1. ***Remember***	2. ***Understand***	3. ***Apply***	4. ***Analyze***	5. ***Evaluate***	6. ***Create***
A. ***Factual Knowledge***	Objective 1					Objective 3
B. ***Conceptual Knowledge***		Objective 2			Objective 4	Objective 3
C. ***Procedural Knowledge***						
D. ***Metacognitive Knowledge***						

Figure 2. The classification in a Taxonomy Table of the four objectives of Ms. Airasian's unit integrating Pre-Revolutionary War colonial history with a persuasive writing assignment.

Conclusion

The Taxonomy of Educational Objectives is a scheme for classifying educational goals, objectives, and, most recently, standards. It provides an organizational structure that gives a commonly understood meaning to objectives classified in one of its categories, thereby enhancing communication. The original Taxonomy consisted of six categories, nearly all with subcategories. They were arranged in a cumulative hierarchical framework; achievement of the next more complex skill or ability required achievement of the prior one. The original Taxonomy volume emphasized the assessment of learning with many examples of test items (largely multiple choice) provided for each category.

Our revision of the original Taxonomy is a two-dimensional framework: Knowledge and Cognitive Processes. The former most resembles the subcategories of the original *Knowledge* category. The latter resembles the six categories of the original Taxonomy with the *Knowledge* category named ***Remember***, the *Comprehension* category named ***Understand***, *Synthesis* renamed ***Create*** and made the top category, and the remaining categories changed to their verb forms: ***Apply***, ***Analyze***, and ***Evaluate***. They are arranged in a hierarchical structure, but not as rigidly as in the original Taxonomy.

In combination, the Knowledge and Cognitive Process dimensions form a very useful table, the Taxonomy Table. Using the Table to classify objectives, activities, and assessments provides a clear, concise, visual representation of a particular course or unit. Once completed, the entries in the Taxonomy Table can be used to examine relative emphasis, curriculum alignment, and missed educational opportunities. Based on this examination, teachers can decide where and how to improve the planning of curriculum and the delivery of instruction.

Notes

1. *The Taxonomy of Educational Objectives: Handbook II, The Affective Domain* was published later (Krathwohl, Bloom, & Masia, 1964). A taxonomy for the psychomotor domain was never published by the originating group, but some were published by Simpson (1966), Dave (1970), and Harrow (1972).
2. The revised Taxonomy is published both in a hardcover complete edition and a paperback abridgment, which omits Chapters 15, The Taxonomy in Relation to Alternative Frameworks; 16, Empirical Studies of the Structure of the Taxonomy; 17, Unsolved Problems; and Appendix C, Data Used in the Meta-Analysis in Chapter 15.
3. Terms appearing in the original Taxonomy appear in italics with initial caps; terms in the revised Taxonomy add boldface to these specifications.
4. *Problem solving* and *critical thinking* were two other terms commonly used by teachers that were also considered for inclusion in the revision. But unlike *understand*, there seemed to be no popular usage that could be matched to a single category. Therefore, to be categorized in the Taxonomy, one must determine the intended specific meaning of *problem solving* and *critical thinking* from the context in which they are being used.
5. One can use the subcategories to designate the rows and columns; however, for the sake of simplicity, the examples make use of only the major categories.

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Paul R. Pintrich

The Role of Metacognitive Knowledge in Learning, Teaching, and Assessing

As Krathwohl (this issue) states, the revised Taxonomy contains four general knowledge categories: Factual, Conceptual, Procedural, and Metacognitive. While the first three categories were included in the original Taxonomy, the Metacognitive Knowledge category was added. The purpose of this article is to discuss the Metacognitive Knowledge category and its implications for learning, teaching, and assessing in the classroom.

Metacognitive knowledge involves knowledge about cognition in general, as well as awareness of and knowledge about one's own cognition. One of the hallmarks of psychological and educational theory and research on learning since the original Taxonomy was published is the emphasis on helping students become more knowledgeable of and responsible for their own cognition and thinking. This change cuts across all the different theoretical approaches to learning and development—from neo-Piagetian models, to cognitive science and information processing models, to Vygotskian and cultural or situated learning models. Regardless of their theoretical perspective, researchers agree that with development students become more aware of their own thinking as well as more knowledgeable about cognition in general. Furthermore, as they act on this awareness they tend to learn better (Bransford, Brown, & Cocking, 1999). The labels for this general developmental trend vary from theory to theory, but they include the development of metacognitive knowledge, metacognitive awareness, self-awareness, self-reflection, and self-regulation.

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Although there are many definitions and models of metacognition, an important distinction is one between (a) knowledge of cognition and (b) the processes involving the monitoring, control, and regulation of cognition (e.g., Bransford et al, 1999; Brown, Bransford, Ferrara, & Campione, 1983; Flavell, 1979; Paris & Winograd, 1990; Pintrich, Wolters, & Baxter, 2000; Schneider & Pressley, 1997). This basic distinction between metacognitive knowledge and metacognitive control or self-regulatory processes parallels the two dimensions in our Taxonomy Table.

Metacognitive knowledge includes knowledge of general strategies that might be used for different tasks, knowledge of the conditions under which these strategies might be used, knowledge of the extent to which the strategies are effective, and knowledge of self (Flavell, 1979; Pintrich et al., 2000; Schneider & Pressley, 1997). For example, learners can know about different strategies for reading a textbook as well as strategies to monitor and check their comprehension as they read. Learners also activate relevant knowledge about their own strengths and weaknesses pertaining to the task as well as their motivation for completing the task. Suppose learners realize they already know a fair amount

By Kristen Kennedy

Writing with Web Logs

An emergent genre is making a space for students to publish online.

Blogging Tools

Check out these options for content management and online publishing.

Commercial blogging software can get you up and running faster and with broader functionality than some of the free offerings that may be full of advertising. UserLand.com, PostNuke.com, pMachine.com, and MoveableType.org offer full-featured publishing tools at reasonable prices.

Virtual learning platforms, such as blackboard.com and WebCT.com, also provide a variety of template-based publishing options.

Find free Web-based blogging tools at Blogger.com, LiveJournal.com, and Xanga.com; add features for a fee.

Blogs in Education

Visit these sites for models and best practices.

Check out Will Richardson's professional and student blogs at weblogg-ed.com.

Web logs created by teacher Peter Ford and middle school students from the British School of Amsterdam are available at class6f.bsablogs.com/stories/storyReader$226.

Links to Pat Delaney's insights and articles on blog technology: interactiveu.berkeley.edu:8000/PatD/stories/storyReader$479.

The Web has opened up almost limitless possibilities for publishing. With so many online magazines, newspapers, and journals, there's no shortage of venues for both professional and practicing authors. Stephen King may be the best-known writer to dabble in self-publishing online, and many have followed his lead. Educators have also been using the Web to publish course descriptions and syllabi, while building professional development communities dedicated to sharing best practices.

Publishing student writing, however, has yet to gain widespread adoption in middle and high school English classes, a fact that seems particularly striking when you consider the advantages of inviting readers to respond to student-authored work. For starters, Web publication gives students a real audience to write to and, when optimized, a collaborative environment where they can give and receive feedback, mirroring the way professional writers use a workshop environment to hone their craft. Jeff Golub, technology spokesperson for the National Council of Teachers of English, says that the organization supports the use of Web-based publishing tools to celebrate and share student writing. Golub, who is also associate professor of English education at the University of South Florida, teaches future educators three central principles about encouraging student authorship: "Students will write when they have something to say, when they have an audience, and when they get feedback."

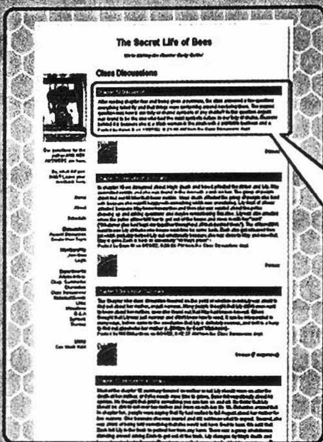
The challenge, as it so often is with new uses of technology, is integration. How do educators take advantage of the Web's publishing tools with limited time and resources and in keeping with the standards? Enter a promising new use of technology called Web logs—or blogs, for short. Part Web site, part journal, part free-form writing space, blogs have the potential to enhance writing and literacy skills while offering a uniquely stylized form of expression.

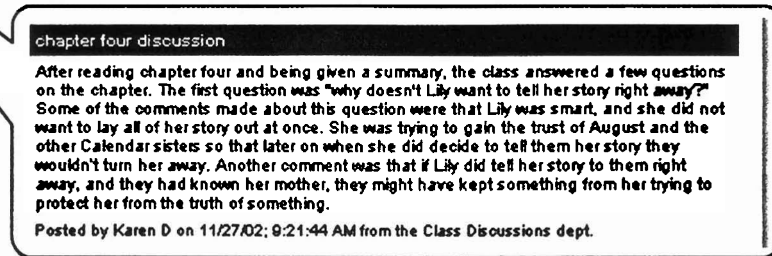
What Is a Blog?

Web logs started out primarily as a self-publishing movement for both professional and armchair journalists making their voices heard in an open online press. For some, blogging—the act of writing and publishing to a blog—takes the form of a digital diary, such as those found at studentcenter.org. And for a handful of educators experimenting with this new genre, blogs offer them and their students an interactive and immediate publishing tool.

What makes Web logs unique is their emphasis on publication and their signature as a dynamic genre of Web writing. Forming the technical backbone of blogs are content management programs, such as PostNuke or UserLand's Manila, that are built to be "personal publishing systems," as UserLand president and COO John Robb puts it. No HTML is required, since these programs are designed to be as easy to use as a word processing application, but with additional collaboration and communication features. Manila, for example, can manage 500 individual student sites, discussion boards, mail bulletin functions, and digital portfolios all with site search and syndicated news stream capture capabilities.

Unlike most Web sites, which generally combine static and dynamic features, a blog is produced with an active writer in mind, one who creates in an online writing space designed to communicate an identity, a personality, and most importantly, a point of view.





chapter four discussion

After reading chapter four and being given a summary, the class answered a few questions on the chapter. The first question was "why doesn't Lily want to tell her story right away?" Some of the comments made about this question were that Lily was smart, and she did not want to lay all of her story out at once. She was trying to gain the trust of August and the other Calendar sisters so that later on when she did decide to tell them her story they wouldn't turn her away. Another comment was that if Lily did tell her story to them right away, and they had known her mother, they might have kept something from her trying to protect her from the truth of something.

Posted by Karen D on 11/27/02; 9:21:44 AM from the Class Discussions dept.

Students in Richardson's American Literature course use their class blog to discuss The Secret Life of Bees *with each other and author Sue Monk Kidd.*

Blogging in English Class

Will Richardson's weblogg-ed.com is a virtual goldmine of blogging resources, including best practices, educator blogs, and technology recommendations for choosing content management tools. A Hunterdon Central Regional High School English teacher from Flemington, N.J., Richardson is among the few educators starting to explore Web logs in the writing classroom.

Journalism at Hunterdon is a paperless course, with all student work posted exclusively to a class blog. Working collaboratively, students select stories from online newspapers to post to their section, with group editors meeting with Richardson to choose the top story of the day. Individually, kids select a beat to cover throughout the quarter, collecting stories and then writing about them at the end of the term. Richardson has found discussion tools the most helpful feature of his Journalism Web log, noting that the online interaction "provided students an opportunity to articulate their ideas in ways they haven't been asked to before."

In American Literature, students post their responses to a class reading of Sue Monk Kidd's *The Secret Life of Bees*. The class blog includes commentary, criticism, and artistic interpretations of key passages and literary images from the novel. Best of all, students got to ask Kidd questions about her writing when she made a virtual appearance on their site. Meanwhile, Richardson has invited parents to read along with the class and publish to their own book club blog.

While only a few months into his blogging experiment, Richardson sees some impact on the way students are approaching their writing. "My kids are more aware of what they're writing and of the potential audience they're writing for," he says.

While still in the early stages, blogs in education are starting to catch on. The National Writing Project recently purchased server space to see how the medium facilitates dialogue and sharing of best practices among teachers who teach in writing-intensive classrooms. Last summer, students attending three local NWP Young Writers' Camps joined in online writing workshops using blogging technology. Camp teachers modeled this experiment after the NWP's E-Anthology, a Web log of educators working together to develop and support each other's writing.

The Challenge of Assessment

In many ways, blogs combine the best elements of portfolio-driven courses, where student work is collected, edited, and assessed, with the immediacy of publishing for a virtual audience. Content management platforms on which blogs are built make this entire process easier and more efficient. But while new uses of Web-based applications can make writing more real for students, educators will still need to consider how to evaluate what happens when students write online. Here are a few places to start when evaluating students' Web logs.

- Start slowly by asking students to post once a week in response to a specific assignment. Allow them to customize and personalize their site as much as their Web log application and school policies will allow. With that freedom comes responsibility, so spend a class drafting the rules for publishing to their sites. Have each student sign a copy, and keep it on file.

- Optimize the journal format by evaluating student writing over time, not just in one high-pressure testing event. Schedule several formal assessments during the school year at which time you can give a term grade that will be averaged with grades from subsequent evaluations.
- Involve students in their own assessment. Assign a written self-evaluation students can submit before giving term grades where they reflect on their strengths and weaknesses. Ask them to provide two examples of where their writing is strongest, where it's weakest, and what they need to focus on for the remainder of the course.
- Encourage students' development of voice by giving two grades, one for grammar and one for style.
- Build rubrics that evaluate quality, not just quantity. Co-authors Stephen Valentine, a finalist in this year's *T&L* Ed Tech Leaders of the Year program, and Gray Smith write about this challenge in *Writing in a Wired World: Improving Student Writing Using a Computer*, forthcoming from Teacher Created Materials. To encourage substantive discussion in student message board communication, they've developed conversation assessments using a five-point rubric that outlines the key criteria for determining a student's grade, including use of evidence, engagement with the text, and whether or not a student responded thoughtfully.
- Use models. Bookmark examples of well-written blogs. Take a class period to discuss what an effective post looks like. The same goes for examples of helpful reader response. If you use discussion board features to workshop students' writing, you also need to guide and reward the difficult work of learning how to give constructive criticism.

For additional digital writing resources, including sites where students can publish their work, visit us at www.techlearning.com.

The Politics of Online Publishing

If blogs are so easy to use and so invaluable for motivating student writing, then why aren't more students publishing online? According to Web log pioneer Pat Delaney, librarian at Dr. Martin Luther King Jr. Academic Middle School in San Francisco, Calif., and associate director of technology for the Bay Area Writing Project, "The barriers are permission and server space. Most schools want to set up an intranet where a Webmaster can approve new content and then push some of it live." But if you have 75 students all posting to a class blog, it's going to take a prohibitively long time to evaluate students' work, aside from the fact that publishing on a school intranet defeats the goal of publishing for a broad audience. Delaney adds, "If you limit students' power by wrestling over permission to publish, then they'll ignore technology use in school."

One solution adopted at King is to make sure all students posting online have parental permission and that they don't publish any identifiable pictures of themselves. Teachers can password protect their sites, as well. For those just starting to blog, Delaney suggests contacting their local National Writing Project office to inquire about blog-based programs. Free Web-based tools, such as Blogger and LiveJournal (see "Blogging Tools," page 11), are also available.

If the fear of giving students an open forum to publish to their personal Web pages without an editor's approval keeps schools from exploring Web logs, consider that self-publishing encourages ownership and responsibility for content. UserLand COO John Robb notes, "Web logs are attached to an individual in the way a discussion board isn't. There are rules to using a Web log. If students break them, they can lose their site."

The impact of such technologies on students who've used them regularly offers a picture of what happens when they're given the freedom—and responsibility—to publish their own work. For example, student editors of the King online newspaper, after attending a school dance late one Friday evening, went home and posted their reports. "That never happens," Delaney says. "Not in middle school." Nadine G., a student from Richardson's Journalism class, wrote in her evaluation of the course, "My Web log became a personal voice for me, and I found I could express opinions, even in my class work. It also helped me organize all my work in one place."

Entering a Conversation

Creating online communities where student writing takes center stage means inviting audiences to read and reflect on published work. For educators, this involves reaching out into virtual and professional communities for collaborative opportunities. For instance, working writers and journalists could volunteer to serve as editors of student blogs. Additionally, alliances between K–12 and higher education would benefit preservice teachers who could gain valuable teaching and technology experience responding to student blogs, while students would benefit from having reliable readers critiquing and encouraging their work. A partnership of this kind started last fall between Middlebury College students and fifth-graders from Shoreham Elementary School in Vermont. Mentors guided students' writing using blog discussion and writing tools. Hector Vila, Ph.D., associate director of distance education for the Center for Educational Technology at Middlebury College, is convinced of the effectiveness of this emerging technology on K–16 education. "This is the sort of collaboration that will get technology into schools," he says. ■

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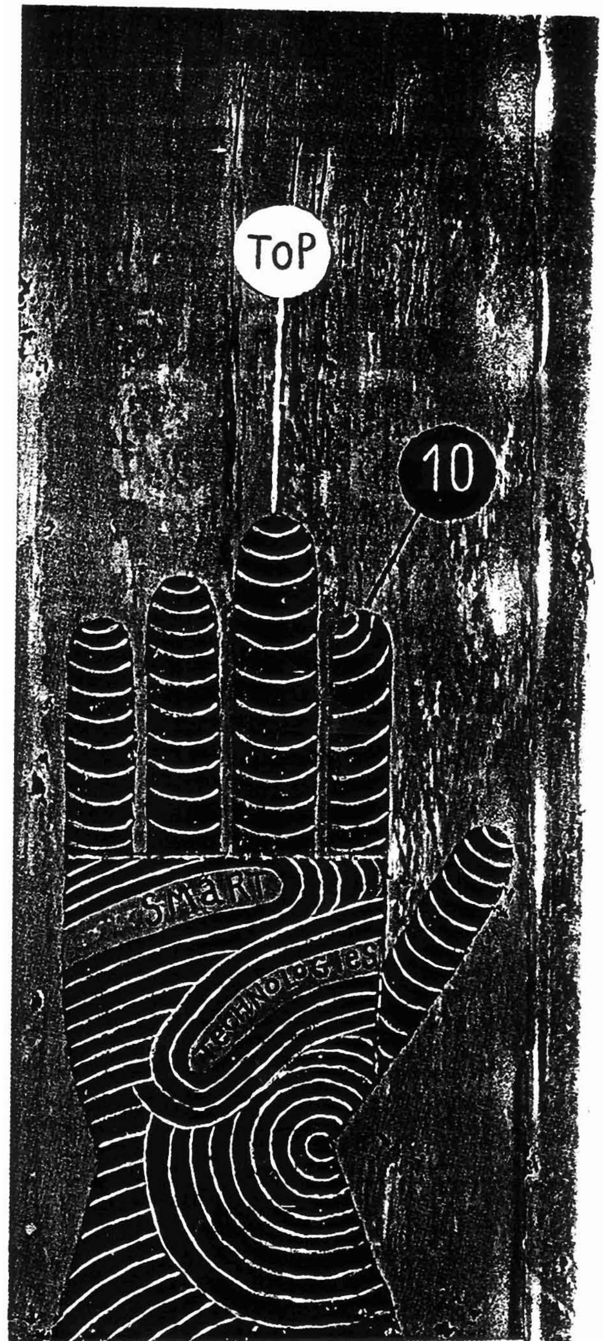
TOP 10 SMART TECHNOLOGIES FOR SCHOOLS



❶ **Voice to Text** From disabled students to administrators on the go, many will benefit from the speedier and broader access to literacy made possible through VTT.

❷ **Next Wave Mobile Computing** Which tools hold the most promise as the best wireless solutions for schools?

❸ **Hybrid Computing** From robots to interactive "talk back" books, hybrid technologies put a new spin on traditional play and work.

❹ **Virtual Reality** Students are gaining unprecedented hands-on experience and advancing intellectual exploration with VR.

❺ **Artificial Intelligence** With the help of computer applications that think like humans, teachers get a boost in targeting instruction to meet the unique needs of each student.

❻ **Telementoring** An entire world of subject-area expertise is available to both educators and students through interactive online environments.

❼ **Assessment on the Fly** A new class of assessment tools streamlines diagnostic and evaluation processes.

Digital Video Production DV combines the dual challenges of scripting a compelling narrative and applying technology know-how.

❾ **Fingerprint Recognition** Automating attendance and other "busy work" tasks and increasing personal security are just a couple of the revolutionary uses of this technology for schools.

❿ **The Brain** Recent findings in neuroscientific research yield exciting discoveries about brain circuitry and learning.

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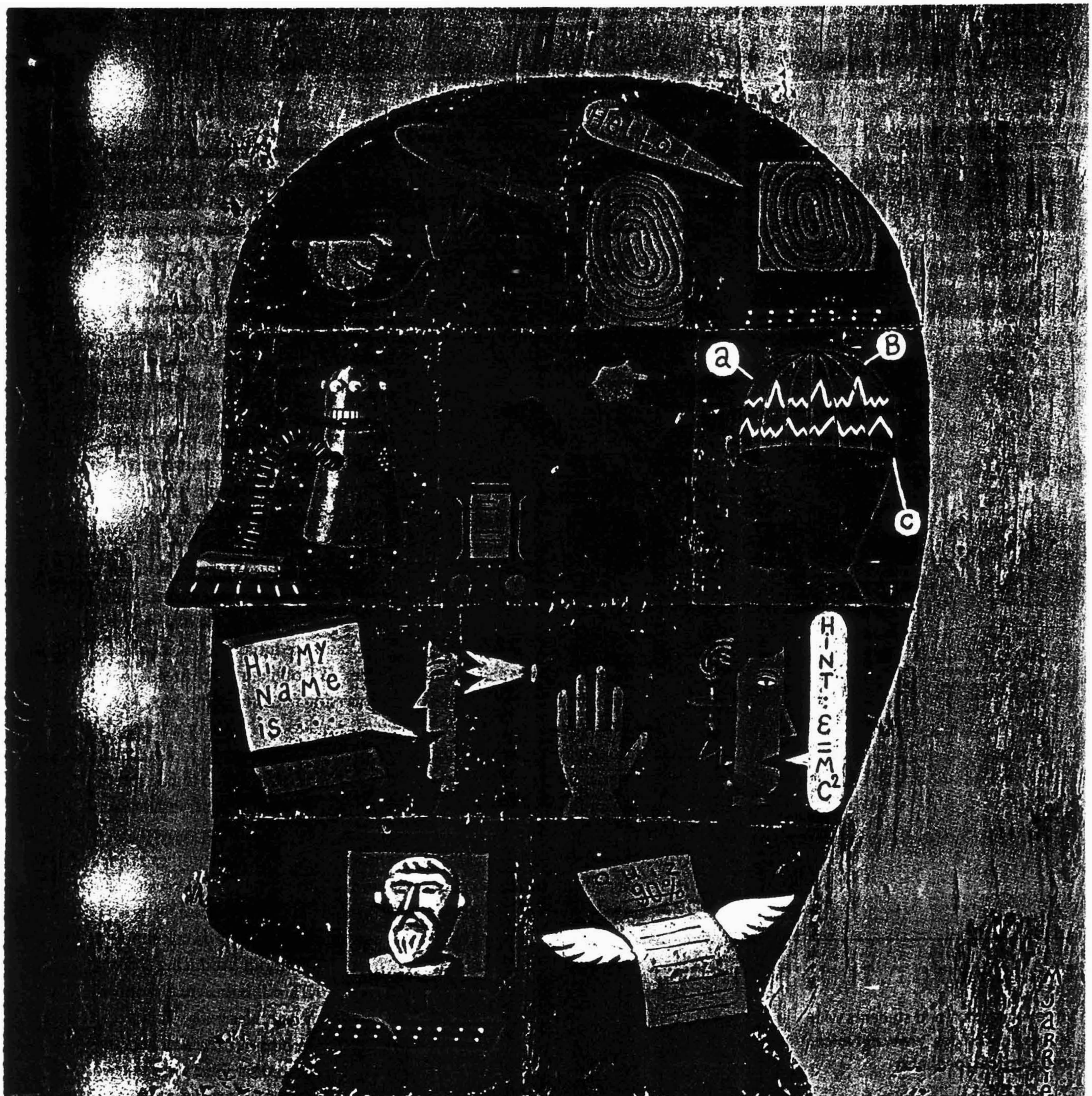
Kathy Schrock, administrator for technology at Nauset Public Schools in Orleans, Mass., and the creator of Kathy Schrock's Guide for Educators (discoveryschool.com/schrockguide)

David Warlick, director of The Landmark Project (landmark-project.com) and the author of *Raw Materials for the Mind*



What's a "smart" technology? While one might argue that all technology—from a toaster to a moon rover—is smart, those we present in the following Top 10 list meet their own set of criteria. In contrast to the breakthroughs we profiled last year, which included such broad topics and trends as wireless and virtual learning, the technologies we've chosen to examine here perform more specific, identifiable functions. Fingerprint recognition and artificial intelligence can free educators and school staff of time-consuming tasks. Telementoring and virtual reality enable collaborations and instant expert guidance from any spot on earth. And voice-to-text technology and hybrid devices support young and challenged learners in formerly unheard of ways. In the hands of well-trained educators, these technologies can offer powerful new solutions for teaching children. —*Susan McLester*

❶ Voice to Text

A language learner pronounces a word and immediately sees it in text on a computer screen. A principal dictates to-do activities while driving to school and arrives with a list on his handheld. VTT offers a whole new level of support for literacy.

By Jason Ohler

The next step in the evolution of writing technology is just as magical as the shift from typewriter to word processor: voice to text. Simply put, voice-to-text technology allows you to speak into a microphone and watch your words appear on your computer screen as a word processing file. Current options allow you to talk to your computer as well as to handheld recorders, which then download to your computer.

While VTT has made great strides in recent years, there are still some kinks that need working out before it's entirely feasible for classrooms. For starters, the software needs to be

trained to understand your voice—which can take anywhere from four to eight hours—and you will need to teach it words that it doesn't know. As of this writing, mainstream packages like Dragon NaturallySpeaking and ViaVoice have achieved about 90 percent to 95 percent accuracy. Rumors persist that VTT is approaching nearly 100 percent accuracy, but we haven't seen it yet. In the near future, it will be as commonplace to include VTT in a computer purchase as it is to include a DVD/CD-ROM drive today. Microsoft already has plans to include VTT in its much-awaited Tablet PC.

Beyond the training time required, there are additional justifiable concerns about VTT. Whereas the word processor has greatly improved upon the typewriter, VTT offers a more dramatic change—primarily because writing and speaking are two very different ways of communicating. It is much easier to say words you may later regret than it is to type them. The slowness of the medium of pen and paper or typing allows for reflection time as one composes. If word processing reduced this reflection time, VTT obliterates it. Any deep processing needs to come later. Also, we'll need to give new consideration to the fact that the tone of voice and body language we use to imbue speech with meaning does not translate when spoken words are converted to words on a screen. Another major stumbling block for VTT in classroom use will be the noise factor: how do twenty-five kids talk simultaneously without producing chaos?

But VTT still holds great promise for teaching and learning. This technology can be a tremendous help to students with disabilities who may not possess the motor skills for handwriting or typing. And those with more oral/aural learning styles can benefit greatly from programs such as Soliloquy's Reading Assistant, which incorporates VTT to allow early reading students to match a phonetic concept with the printed word. English Language Learners as well as foreign language learners can also boost fluency, pronunciation, vocabulary, and other skills through software that integrates VTT.

VTT's most immediate use in mainstream education will probably be as the preferred method for "quick writes," in which students sketch out an idea for a paper or report before

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Voice recognition and students with learning disabilities: **www.ngtvoice.com/services/peel.htm**

Harnessing voice recognition for e-learning solutions: **www.alleninteractions.com/voicerec/dialogcoach.htm**

Super voice recognition that mimics the way the brain interprets speech:

ATYTT/voicerecognition.htm

Training materials and information on a speech recognition project in 40 schools: **callcentre.education.ed.ac.uk/SEN/5-14/Special_Acc_FFA/Speech_Recog_FFB/speech_recog_ffb.html** doing serious editing with a word processor. It will also likely be adopted to facilitate activities in which speech is conventionally converted to text, like brainstorming or taking field notes and minutes of meetings. It offers potential efficiency for use with many things that are now primarily written, including tests, assessment, notes to parents, and homework. As long as VTT is linked to improving either the quality of writing or the ability to produce written words, it will have a place in education.

And as with all new technologies, VTT will first do the work of its predecessors and then create entirely new kinds of activities we can't imagine yet—artistically, educationally, and commercially.

❷ Next Wave Mobile Computing

Laptops, handhelds, tablet PCs or customized combination devices—what options are out there for schools?

By Susan McLester

What does the dream mobile computing device look like? A lightweight, low-cost, pocket-size, secure, durable, Internet-connected, e-mail-ready, powerful, wireless network–enabled, peripheral-friendly, memory-rich, expandable computer, with pager and phone? For some, perhaps. But as high-end integrated solutions such as Handspring's Treo and Palm's new Tungsten W duke it out for the perfect mobile combination, many schools are still grappling with the why, how, and, of course, how much.

What does mobile computing offer schools? The first and most obvious answer is: freedom to pursue learning anytime, anyplace. But with price, ruggedness, battery life, security, and tech support among the prime considerations in the education environment, finding a comfortable mobile match for schools is not easy. Everyone seems to agree that wirelessly connected computers are our future. And for schools, where outdated infrastructures, portable classrooms, and space constraints are often a fact of life, wireless makes a lot of sense.

Since Microsoft's pioneering Anytime Anywhere Learning program first put laptops in the hands of students and educators back in 1996, wireless technology has become increasingly accepted in K–12 education. Since then, wireless carts have allowed budget-strapped schools to get more from their technology dollars through the sharing of laptops among several classrooms. But research shows a greater benefit of wireless for schools is its potential to empower and motivate students with their own Internet-connected personal digital devices for home, school, or anywhere. And though laptop programs still remain a very viable option for some schools, their high price, bulk, and risk for theft make them less than ideal for many others.

A lower-priced alternative schools have experimented with is the handheld, whose light weight and suitability for certain tasks—such as note taking, real-time scientific measurement in the field, or information management on the fly—have carved it a niche in certain areas of education. However, the scaled-down capabilities of most handhelds—the tiny screen, lack of a keyboard, and reduced memory and processing power—make it impractical for performing many of the tasks a laptop or desktop can.

In general, hardware companies in both consumer and education worlds are competing to create the device that becomes that elusive "missing link" between the handheld and full-blown laptop or desktop. One promising newcomer for the school market is AlphaSmart's Dana, a lightweight, low-priced, Palm OS–enabled device which offers Internet connectivity, a full-size keyboard, PC-width screen, and the teacher-friendly

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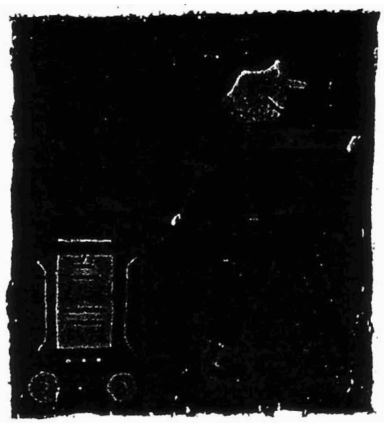
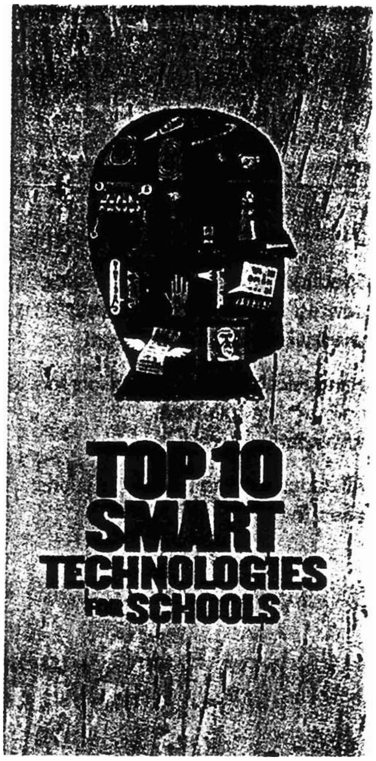
Specific-function mobile computing devices: www.education.ti.com; www.wirelessgeneration.com

Handhelds and wireless sensors for science data collection: www.datastick.com

All about the new tablet PC options: www.infocater.com





option to disable the beaming function, which many fear has encouraged cheating.

Tablet PCs are another option currently being brought to market by Microsoft, Acer, and others. Thin and lightweight, they offer sophisticated handwriting recognition software that can transcribe even quickly scribbled notes into typed text. For those new to technology, no Graffiti training is necessary, and they're great for users on the go, with voice recording and single-handed writing capabilities. Acer's TravelMate incorporates both laptop and handheld, converting from the "clamshell mode" for keyboard input into a folded-down tablet for pen use. At this point, drawbacks to tablets include a high price tag, fragility, and a stylus with an embedded circuit board that is prohibitively expensive—around $50—to replace.

But as the technology becomes increasingly sophisticated and options broaden, it may be that we move toward not just a single solution, but a few devices with narrower, more dedicated purposes, such as the cell phone. Palm's new $99 Zire targets users who primarily want a tool for personal information management. The higher-end Tungsten T has one-handed navigation, voice recording, [illegible] enabled cell phone, printer, scanner, and so forth could all receive commands from the handheld. It's possible that in the future PANs might find a home in classrooms for collaboration projects, or simply as time-saving devices.

With the technology evolving at such a rapid rate and educators only just beginning to investigate the imaginative approaches to learning it makes possible, it's difficult to predict which specific mobile device or devices will be the best fit for students and teachers. What we can predict, however, is that they'll be more powerful, more versatile, and more commonplace in schools.

❸ Hybrid Computing

Toys that think, probes that process, books that talk out loud—hybrid technologies challenge our notions of what it means to be a computer.

By Charles Parham

Is it a computer or isn't it? The shrinking size and price of microprocessors has encouraged the development of a number of fascinating hybrid computer products. Some take the form of interactive toys and books. Others blend data-gathering peripherals with handheld devices. What they all have in common [illegible] blurring the lines between hardware and software more than ever before.

Robots have been around since the birth of educational computing, but until recently, the actual building and manipulating of mechanical devices largely remained in university laboratories. All this is changing rapidly. Pitsco/LEGO Dacta has developed a computerized LEGO brick that functions as the "brains" of robotic devices that do everything from playing soccer and taking digital photos to tracking the activity of a guinea pig in its cage. More finely engineered preassembled robots from

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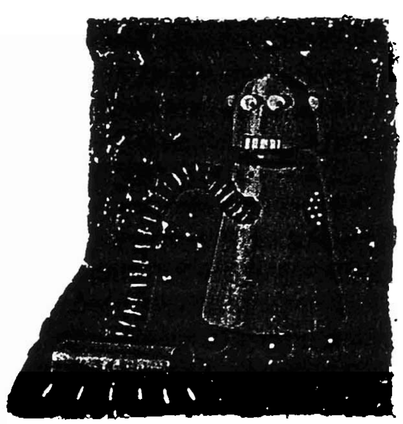
Kits and tips for building your own robot: **www.amigobot.com; www.educational-robots.com; www.pitsco-legodacta.com; www.knexeducation.com**

Explore using probes in the K–12 setting: **www.concord.org/probesight**

A sampling of smart pads: **www.compasslearning.com** (PlayBox Theme Time); **www.educationalinsights.com; www.leapfrogschoolhouse.com; vtechkids.com**



companies such as Educational Robot Company and ActivMedia Robotics can send in attendance slips, run a vacuum, or stealthily take a camera to the science room down the hall.

Despite what science fiction movies might lead us to believe, robotics systems are not plug-and-play devices. Teachers and students need to develop relatively complex problem solving and programming skills to bring them to life.

Another hybrid computing trend is the pairing of electronic sensors, or probes, with handheld devices for scientific data collection. Although probes have been around for some time, the increasing ubiquity of inexpensive USB-connected handheld devices is spurring their widespread adoption in schools. It's now easy for teachers to take students out with a set of pH and temperature probes to monitor water quality in streams and ponds, to set up motion detectors, and most importantly, to work with real data, as opposed to that which has been "cleaned up" for math and science textbooks. Information can be fed into spreadsheets and either reviewed on-site or taken back to a classroom computer for further work.

While robots and scientific probes have been part of the university curriculum for a number of years, and are increasingly finding a home in the K–12 classroom, "smart pads" are relative newcomers to schools. These interactive pads, descendants of the electronic matching machines of the 1950s, usually include a stylus and voice synthesizer that allow users to touch a specific area of the pad—such as a single sentence or a picture—and receive feedback. For example, students using LeapFrog SchoolHouse's LeapPad can point at a word in a storybook (placed into a proprietary electronic platform) and hear it read back to them. Electronic pads provide instruction in a wide range of areas, from early reading to geography, and are proving very useful to educators as support for basic skills.

As computer chips continue to be integrated into familiar objects found in the classroom, and embedded in increasingly smaller and more powerful handheld devices and their peripherals, our metaphors for computing will change and so will the landscape of schools. Computers won't just exist in a lab or in the back of a classroom, but instead will be part of a variety of learning tools that seamlessly merge with the objects of everyday life.

4 Virtual Reality

The next wave of VR promises experiences so real you can almost feel them.

By David Warlick

Few applications have inspired as much excitement and speculation as virtual reality. Coined almost 20 years ago by technology evangelist and computer scientist Jaron Lanier, the term virtual reality still retains its cache as the exclusive domain of futurists. However, the reality of virtual reality is that we use it in its most basic form every time we select computer-generated file folders and documents that look like pieces of paper. Increasingly popular forms of VR also include Apple's QuickTime, a common VR application used by prospective college students, allowing them 360-degree panoramic views of university campuses. Budding artists also use QTVR when they want to take a virtual visit to the Louvre.

With its head-mounted displays, data gloves, and navigation tools, immersive VR has inspired the most excitement. By offering the user an interactive physical and intellectual experience impossible in the real world, immersive VR blurs the line between human-computer interaction. As the wearer of a head-mounted display turns his or her neck to operate the navigator, the computer environment conveys the irresistible illusion

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More about QuickTime Immersive Imaging: **www.mastery.com.au/qtvr**

A QTVR Tutorial for Educators: **www.edb.utexas.edu/teachnet/QTVR**

Read about VR for assisted learning at **vreal.orlando.veridian.com**

The next wave of VR will rely on tele-immersive environments supported by Internet2: **www.internet2.edu/html/tele-immersion.html**

To visit the Louvre in Paris, log on to **www.louvre.or.jp/louvre/QTVR/anglais**

of moving within a real space among tangible objects. In the classroom, this technology may one day take students beyond the textbook to virtual settings where they might engage in tactile experiences exploring the surface of Mars, a 12th-century castle, or the inside of an amoeba, learning experiences not possible with traditional teaching tools, such as a chalkboard or textbook.

We may not have to wait too long for VR-equipped classrooms, given the pioneering work that's going on in one Florida elementary school. Hearing-impaired students in Orange County are using VREAL, which stands for Virtual Reality Education for Assisted Learning, to practice life skills as well as math and reading. Equipped with joysticks and high-resolution monitors, kids learn how to navigate their hometown and ask people questions in simulated real-life encounters. When needed, a sign language interpreter appears on screen to help students. Such practice gives them confidence to face social situations they may be avoiding because of their hearing impairment.

While most students have experienced VR technologies in the form of computer games, in the science classroom of the future, they will manipulate chromosomes on a strand of DNA and view the resulting permutations—without the moral and physical consequences. In time, students who once listened to a physics teacher lecture in class might slip on their VR glasses and find themselves in Albert Einstein's study, talking with the scientist about quantum mechanics, or better yet, inside of an electron, experiencing the behavior of quantum particles. Already, health professionals are benefiting from the introduction of highly sensitive haptic technologies—the sense of touch delivered via data gloves or instruments—into virtual reality environments. Cardiologists are performing virtual heart transplants with surgical simulations that allow them to train in non-life-threatening situations. In the future, the high-speed network infrastructure provided by Internet2 and the collaborative potential offered via Web-based videoconferencing will transform classrooms into immersive, tactile environments where remote groups can work together to solve problems and exchange ideas.

5 Artificial Intelligence

They don't do windows—but the next generation of AI applications can teach, tutor, and even grade essays.

By Kristen Kennedy

Just as virtual reality applications have become so much a part of our daily lives we don't even recognize the science behind the display, so too have artificial intelligence–based technologies. For instance, voice and character recognition are now invaluable aids in assisting struggling readers and writers with text entry and word recognition. Script writing and recognition intelligence is powering your handheld, translating the chicken scratch of Graffiti into readable form. Toward the goal of making computers that think like humans, AI is now making new inroads into K–12 education with writing assessment engines and smart tutoring systems.

Trained to evaluate and guide students as they work through problems, AI applications are programmed using models—whether that's the intellectual behavior of a student working on a math problem or a range of prescored essays—to evaluate and instruct.

While many English teachers balk at the prospect of hiring a computer to assess the interpretive art of essay writing, it is already happening in schools. IntelliMetric, marketed by Vantage Learning as My Access, is a

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Home site of SRI's AI Center: **www.ai.sri.com**

For all things AI, the American Association for Artificial Intelligence: **www.aaai.org**

A handy reader-friendly introduction to AI: **library.thinkquest.org/2705**

Web-based system that lets students draft and submit their work online. The program then automatically gives both an analytic and holistic score based on a four- or six-point scale. According to Scott Elliot, COO for Vantage, the IntelliMetric engine claims a 99 percent reliability rate—meaning that 99 percent of the time, the engine's scores match those of humans.

Around-the-clock access to evaluation and feedback, increased scoring reliability, and general efficiency are the reasons Deb Lindsey, director for the Office of Research and Assessment in the Milwaukee Public Schools, adopted My Access. Whereas Milwaukee schools' annual writing exam once took human scorers four weeks to grade, the AI-supported grading engine now delivers results in seconds. The system also offers students roughly a dozen different essay prompts during the school year to help them prepare for the end-of-year exam. With instant feedback, kids can refine their writing and practice new essay strategies without the pressure of a one-shot final exam.

Smart tutoring systems also promise to radically transform our concept of online learning. Dr. Kurt VanLehn, AI researcher and professor of computer science at the University of Pittsburgh, explains that, unlike hypertext-based online learning applications that give students a certain number of chances to find a correct answer before providing the right one, smart tutoring systems act as coaches, offering hints when students stumble in the problem-solving process, not just when they enter an answer. This kind of direct, intuitive instruction is already having an impact on student performance. In pilot studies, learners using VanLehn's Andes physics tutor for homework help improved a full grade on their midterm exams over those using paper and pencil.

When the question is asked—and it always is—about whether computers will eventually become so intelligent they'll replace humans, VanLehn responds, "There's no way that will happen. You can't replace a teacher." A more likely scenario, VanLehn adds, is "a day when seat work takes place at home, with the help of a smart tutor. When students hit a rough spot, the tutor will automatically send a file with the problem to the teacher. When students return to class, the teacher can help them. The system directs human contact where it's most needed."

6 Telementoring

New approaches to online collaboration are changing the way we think about community.

By Doug Fodeman

The concept of a mentor, a wise and trusted counselor or teacher, comes to us from ancient Greece. And while we moderns may benefit from the evolution of technology, the concept of "mentor" remains the same, only the delivery has changed. Many of today's mentoring programs have expanded to include Web-based communication tools to foster learning.

One of the first telementoring

projects began at Hewlett-Packard in the mid-90s, when more than 1,500 employees began using e-mail to tutor math and science students in remote locations. The program has since expanded to become the International Telementor Program, which electronically connects mentors directly with teachers and students.

Online mentoring programs offer

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National School Network, Telementoring and Mentor Center: **nsn.bbn.com/telementor_wrkshp/tmlink.html**

To set up electronic exchanges with volunteer experts, visit the Electronic Emissary Project: **emissary.ots.utexas.edu/emissary/index.html**; the Virtual Volunteering Project: **www.serviceleader.org**; or **www.telementor.org**

For more on Harvard's WIDE World project: **wideworld.pz.harvard.edu**

valuable and unique channels for discovery. For example, an eighth-grader studying the physics of flight can connect online with the pilot of a major airline, while a high school senior preparing for an AP Latin exam can communicate electronically with a Latin scholar. Already, studies are showing the positive impact of telementoring on student achievement. The Research and Development Center for the Advancement of Student Learning at Colorado State University reported that teachers observed noticeable gains in students' "writing skills, ability to integrate knowledge across subject areas, and improved teamwork" after participating in telementoring projects.

While instant messaging and chat rooms are popular online communication tools among students, most mentoring programs use e-mail because it allows participants more freedom in their time scheduling. Nathan Finch, senior project manager of Harvard's WIDE World Project, which mentors educators globally, says, "Asynchronous mentoring allows reflective learning. As our world expands, time zones make synchronous collaboration difficult to impossible for everyone in a single course."

The WIDE World Project began in 1998 as a single online professional development course with seven participants and one mentor from the Brookwood School in Manchester, Mass. Since then it has multiplied into six courses that involve over 300 participants from more than 40 countries. Brookwood teacher Martha Fox, who serves as a mentor, coaches seven to 10 participants, meeting them in an online social hall, visiting their school Web sites, and generally providing support to those inexperienced with technology. Fox observes that "many learners need the sense that they are part of a wider conversation." She also adds that while many telementoring programs are still struggling with organization, her last mentoring group, which included teachers from Amsterdam, Indonesia, and Japan, was very successful. "The perspectives you get from such a diverse group of individuals are incredible!" she says.

Increased affordability of Web conferencing software and high-speed Internet connectivity will no doubt expand opportunities for remote collaboration. But for both teachers and students, telementoring programs—regardless of the technology they employ—will continue to offer a contemporary approach to a time-honored teaching relationship.

Link Up

Companies whose products offer anytime, anywhere assessments: **www.wgen.net; www.scantron.com; www.testu.com; www.kaptest.com; www.edisonschools.com**

Visit this robust supply of resources for getting started using handhelds in classroom assessment: **education.umn.edu/edutech/PDA/pda_resources.htm**

A point of departure for investigating online assessment: **www.netdaycompass.org/categories.cfm?instance_id=1523&category_id=4**

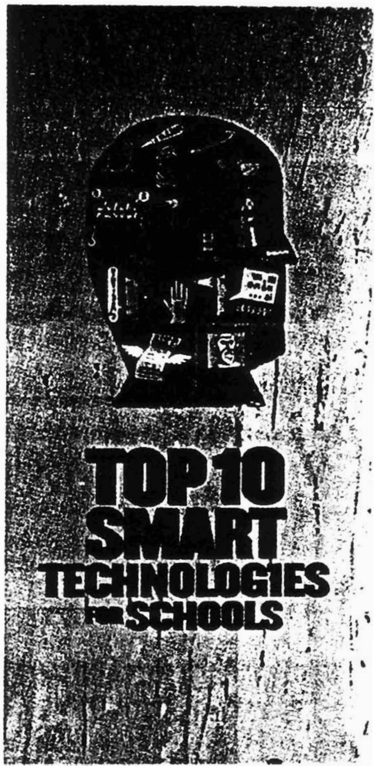
❼ Assessment on the Fly

New technologies lend mobility and speed to traditional testing and evaluation.

By Todd McIntire

As the call for increased accountability converges with the proliferation of handheld devices and broader Web access in schools, educators are embracing the prospect of anytime, anywhere assessment. An emerging class of on-the-fly assessment tools can now optimize the power and portability of handheld and Web technologies to improve the ease, frequency, and authenticity of assessment.

Now capable of running complex applications, today's handheld computers are packed with enough memory to hold thousands of pages of test items and results, which can then



be instantly tabulated and displayed to both teacher and student. More importantly, collected data from handhelds can easily be uploaded to database applications for analysis, and later distributed as reports that show individual assessments, longitudinal trends, and aggregated results for groups of students, classes, and entire schools. With analytical tools so closely within reach, teachers are able to make timely, productive changes in their teaching to better serve students.

Wireless Generation's mCLASS is one such solution. Using a Palm handheld, teachers collect student performance data from standardized tests. For example, mCLASS: Reading enables K–3 teachers to perform reading assessments by automating the creation of a running record, which is traditionally a hand-written observational assessment. Running records require significant teacher time to decode, tabulate, and analyze. With mCLASS: Reading the process is fully automated, so teachers can focus on the results rather than the collection of data.

Web-based assessments offer additional options for brushing up on other achievement tests. TestU and Kaplan K12 Learning Services are but two in a growing line of online testing services that not only offer quick results, but also customize questions to address the test taker's strengths and weaknesses. Improving upon its history with the bubble sheet scanner, Scantron's Classroom Wizard combines Web applications for creating quizzes with handhelds for portability. Students download and complete quizzes on handhelds, and then beam their results to a central computer. As a result, the turnaround time for grading quizzes is virtually eliminated.

At Edison Schools, we developed Benchmarks, an online student assessment application used in all our affiliated sites. Students in grades 2–8 take short monthly online tests in reading, language arts, and mathematics, so teachers can track progress over time by subject matter and specific skill area. The results are then instantly tabulated. Administrators, teachers, students, and parents can access results and together plan the best intervention, if needed.

Quick anytime, anywhere assessment is a smart technology for schools not just because it saves time. The real benefit of new assessment technologies is that time saved in automating assessment can be better spent on improving the ways we teach—and reach—students.

8 Digital Video Production

Using the latest DV technologies, students and educators are becoming directors of their own learning.

By Carol S. Holzberg

Kids have always taken to movie-making. Wielding a camcorder and shooting footage of their peers; developing a storyline to showcase their creative endeavors; and, of course, screening their work all seems to come naturally to them. These days, though, rapid advances in video technologies have allowed students and teachers to take their digital storytelling to new levels.

Unlike analog-based VHS camcorders, digital video can be easily manipulated, transmitted, and projected. That means, for example, students can simply drag and drop high-resolution

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Official iMovie site that includes tutorials, product information, and sample student videos: **www.apple.com/imovie**

Product reviews, news, and tips from the publishers of *DV Magazine* (Editor's note: *DV Magazine* is a sister publication of *T&L*): **www.dv.com**

Examples of student movie-making in action, Amherst, Mass.: **www.arps.org/amhersthistory/townhall/clock/how_the_clock_works.htm**

DV clips into a multimedia report. Or use DV editors like Apple's iMovie or Microsoft's Movie Maker to gather clips from a digital video camera, insert eye-catching transitions to link one clip to another, and apply special effects. Because compressed digital video travels well electronically, students now have a workable option for displaying and distributing their productions online.

Educators have been quick to infuse the conventional curriculum with moviemaking activities that engage students' creative energies while encouraging planning and sequencing skills. In Amherst, Mass., for instance, upper-elementary students used digital video to illustrate historical information about their town. Students shot clips of local landmarks, such as the town hall, and posted them on the Web along with primary source information they gathered on-site and from the local library's special collections. Using a camera successfully, transferring moving images from camera to computer, editing the footage so it tells a story with a beginning, middle, and end—all these activities required hands-on work and critical thinking.

Digital video is also being harnessed in innovative ways for basic skills development. At Shutesbury Elementary School in Massachussetts, second grade teacher Vicki Davey videotapes her students reading passages from their favorite books, then plays the clips and asks them to talk about their reading strengths and weaknesses. After this self-assessment, students reread the passages and are filmed a second time for comparison. The "before" and "after" clips are placed in individual student portfolios and sent home to parents on a CD-ROM. According to Davey, her students' reading abilities have improved dramatically. She attributes this to students having a more concrete audiovisual sense of how they read. Seeing themselves on-screen, they understood exactly what they needed to do to read more fluently.

If we accept the notion that the best kind of education provides children with varied opportunities for analytical thinking, demonstration of concepts learned, and exhibition of academic achievement, then digital video has a role to play in schools. Even more exciting is the technology's potential to inspire both students and educators to flex their imaginations and think of new, multimedia-rich ways to tell their stories.

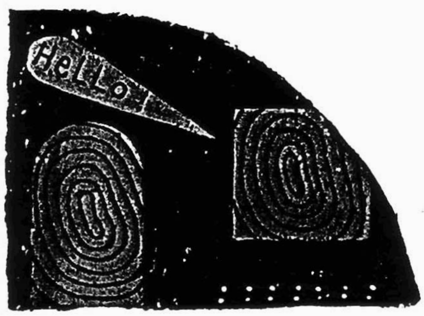
9 Fingerprint Recognition

Check into class, check out a book, log on to the network—fingertip access is the newest way to go.

By Kathy Schrock

Fingerprints have long been used by law enforcement for identification at crime scenes. However, recent advances in technology have expanded the capabilities of fingerprint recognition for a variety of uses in schools. The field of biometrics uses digital technology based on unique physical characteristics, like a retina, fingerprint, or voice, to specifically identify an individual. Fingerprint recognition technology is made up of two parts—a databank of software to tie a fingerprint to a person's identity information and a piece of hardware that verifies a fingerprint matches the one in a stored template.

Fingerprint recognition technology has the potential to eliminate some of the "administrivia" that goes along with identification of students for certain purposes. For example, imagine a small fingerprint recognition device placed in each classroom and tied to the student information system. Each morning, or at the beginning of each period, the student simply presses his or her finger on the fingerprint pad, and attendance is automatically



Link Up

Research paper, "The Body as Password: Considerations, Uses, and Concerns of Biometric Technologies": **www.signelec.com/content/download/these/michelle_frye.pdf**

News article, "Fingerprint Reader Replaces School Lunch Money": **www.usatoday.com/life/cyber/tech/review/2001-01-24-fingerprint.htm**

Fingerprint recognition device vendors: **www.morpho.com/products/products_biometric_morphotouch.htm; digitalpersona.com; www.bioenabletech.com/timetronix.htm; www.secugen.com/products/ph.htm**

recorded in the SIS. The device can also easily act as a hall pass to record when students leave and return to the classroom during the day, in case there is ever a question about their whereabouts.

Another potential use of fingerprint recognition is in conjunction with e-cash. Imagine each student has electronic cash "on account" in a database that is debited when payments are made. They can use the biometric fingerprint device in the cafeteria to pay for lunch (thus eliminating the stigma of the "free lunch" ticket); in the library media center to pay for photocopies or lost books; and even in the school store when buying notebooks or their class ring. This would nearly eliminate the need for students to carry cash to school.

When it comes to learning activities, perhaps the most helpful use of fingerprint technology is for logging on to your school's network without requiring a user name and password. No more need for clipboards with sign-in and sign-out sheets, no worry about students logging on as one another—and no need to change passwords as they are forgotten.

But there are obstacles still to overcome with fingerprint recognition technology in schools. The first is the lack of a clear conduit that allows the different software databases in a school to work together. The Schools Interoperability Framework consortium is currently designing a specification that will allow many types of vendor databases to read each other, which should address this problem.

The other obstacle is one that will involve a bit more discussion. The area of privacy, and keeping students' fingerprints on file at the school, is an important one to talk about at all levels. If you do use this technology, be sure to inform parents of its benefits to the student and the school community at large.

10 The Brain

Can we speed up the brains of language learners so they process words better? Or slow things down for students with attention deficit disorder? Some of the latest technologies offer mind-bending possibilities.

By Amy Poftak

No article about "smart" technologies would be complete without paying homage to the smartest, most complex technology of all: the brain. Like any sophisticated technology, the brain is organized in different parts, or modules, each responsible for carrying out a specific function. These brains-within-a-brain collaborate with each other to carry out a range of tasks, from tying a shoe to learning a foreign language.

Modularity is actually a recent discovery in brain research, thanks in part to advances in imaging technology that allow researchers to peer inside a brain and chart its activity. For educators, modularity means taking another look at the way students think. If a child is having difficulty reading, for instance, a specific part of his or her brain requires intervention. The next logical step, of course,

Link Up

Articles about brain research, interviews with experts, and online professional development courses brought to you by Scientific Learning: **www.brainconnection.com**

Software offerings that incorporate neuroscientific principles: **www.scilearn.com** (language and reading development); **www.mindinst.org** (spatial-temporal abilities); **www.bridgeslearning.com** (motor systems)

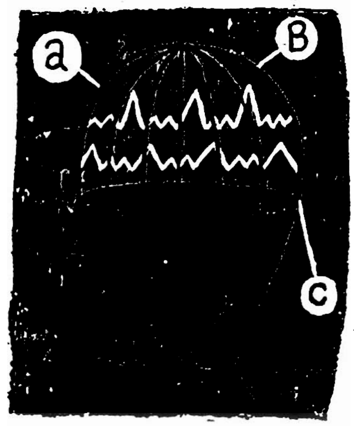
Biofeedback in education: **www.playattention.com**

is finding a technique to address the problem—and that's where technology has a significant role to play.

Or so you'd think. Despite exciting discoveries about the brain's circuitry, surprisingly few commercial technologies are actually based in neuroscientific research. The company best known for connecting their work to brain science is Scientific Learning, which has developed software designed to "train" the brains of language learning–delayed students who have trouble recognizing phonemes and thus hear words all as one sound. The power—and advantage—of the computer is that it can digitally stretch out words so the learner is able to distinguish phonemes. Although this was possible to do over a decade ago, the advent of high-fidelity sound cards and speedier processors, as well as advanced multimedia and adaptive capabilities, have made these programs more effective and emotionally engaging than ever before. Emotional attention is no trivial matter: researchers have found that if a child is bored, so, too, is the brain's mechanism for learning.

Another way technology is being used to maintain attention is through biofeedback, which gives users information about their brain waves so they can learn to control them better. In biofeedback programs that treat ADD/ADHD, for example, students wear a hat embedded with sensors that collect data on their brain waves. The hat then transmits information about brain activity to a computer program. Think of it as a mind-controlled video game: If the user stays focused, he can control the screen action, such as moving a character from left to right. If attention wanes, however, he loses control of the action. The idea is that after 20 sessions or more, the trainee will learn to better regulate the part of his brain responsible for attention. Some studies have shown that biofeedback therapy can be as effective as medication for ADD/ADHD students—even more so in some cases because there are no side effects—but at $2,000 to $5,000 per child for a course of therapy, the cost is presently prohibitive for most schools and families.

Brain scanning is another technology that provides a window into how the brain processes information. For example, using magnetic resonance imaging, UCLA researchers mapped children's brain development over time and found that the most explosive period of growth in the area responsible for language development is between ages 6 and 13. In the far future, some experts predict that scanning technologies



will become a regular part of schools, providing teachers with the ability to map a student's brain activity and tailor instruction to enhance his or her brain's circuitry. Today's brain scanning technologies are extremely expensive and invasive, however, and it will be some time before they ever make it from research institutions to mainstream education.

Until that day, educators will be happy to know that perhaps the most brain-friendly technology available to schools is one they already have access to: the Internet. Dr. Robert Sylwester, an expert on brain science and education, points out that the Web encourages different avenues for exploration and play, and provides multiple solutions to problems—all good practice for kids developing the brainpower needed to navigate the real world. ■

Kid-Proofing Computers

HAVE YOU MONITORED YOUR KIDS TODAY?

What's all the fuss about kids and the dark alleys of the Internet? Isn't the real world every bit as dangerous, or more so? After all, from an early age we warn them about talking to strangers or getting into their cars. But what about online marauders who are after our children, especially teenagers aged 13 to 16, under the cloak of anonymity that the Internet affords them?

According to a bulletin published by the Office of Victims of Crime, a division of the United States Department of Justice, there were an estimated 10 million children in 2001 using the Internet. By 2005, there will be approximately 77 million kids online. Given these numbers, it's not surprising that the Crimes Against Children Research Center at the University of New Hampshire found in its 1999 study that one in five youth had received a sexual approach over the Internet in the previous year.

That survey also showed that nearly half (48 percent) of these predators were other teenagers, The shocking result: one-fourth of the aggressive episodes were initiated by females who wanted access to other teens for purposes of physical assault, bullying, exploitation, stalking or sexual abuse.

While the Internet is a wonderful, fun and educational tool, what this study revealed is that it can also be a very dangerous place to visit.

In October 2003, the Economic & Social Research Council, the UK's leading research funding and training agency, launched the ESRC e-Society. The e-Society is a major four-year research program that will be looking at the impact of digital technologies, particularly the Internet, on society. One of the research projects under this program is UK Children Go Online, a study that focuses on the nature of children's Internet use. >>>

PAM FRANCIS / GETTY IMAGES

In the first report, *UK Children Go Online — Listening to Young People's Experiences*, Sonia Livingstone, professor of psychology at the London School of Economics and principal investigator, talked to 14 focus groups of nine to 19-year-olds about how they used the Internet and their opinions on its safety and value.

The findings of the report confirmed some things that are already known or suspected. Children have become the Internet experts in families, yet they still mainly use the Internet as a means to communicate with friends and relatives and to play music and games. Internet literacy also boosts the self-esteem of youngsters, and both girls and boys gain significant, perhaps even unprecedented, social status through the value that adults place on this expertise.

While the report revealed that messages about the risks of chat rooms and talking to strangers are readily apparent, young children and teenagers are still very trusting, naïve, curious, adventuresome and eager for attention and affection. And these tendencies are exacerbated because children object to being monitored by their parents and often find ways to get around such parental restrictions.

The second report, *UK Children Go Online — Surveying the Experiences of Young People and their Parents* was released in July 2004. Professor Livingstone again studied young people aged nine to 19 (face to face) who go online at least once a week. This second survey included a written questionnaire for the young people's parents.

The results of this second report demonstrate parents' glaring lack of awareness concerning online exposure of any kind that their children have received. In summary, 57 percent of young people have come in contact with pornography online while only 16 percent of their parents say their children have seen porn online. Forty-six percent of young people claim to have given out personal information, yet only five percent of their parents believe their children have done so. And only one in 20 parents appear to be aware that their child has received unwanted sexual or nasty comments online, as opposed to one-third of the young people that said they have actually been approached.

Livingstone says, "Parents need to be aware of the risks their children are facing, especially as eight percent of young users who go online at least once a week say they have met face to face with someone they first met on the Internet, 40 percent say they have feigned some aspect of themselves online, and 10 percent say they seek out online porn deliberately."

"However, simply restricting children's Internet access would deny them many of the benefits. Children are using the Internet for a growing diversity of activities," she says. "Around 90 percent use the Internet for homework, 72 percent for e-mail and 70 percent for games. Further, 55 percent of 12- to 19-year-old daily and weekly users have visited political and or civic sites, and 25 percent have sought personal advice online."

Understanding that no family is immune to the possibility that their child may be exploited and harassed on the Internet, Professor Livingstone offers some recommendations to policy makers, Internet service providers, teachers, parents and children.

Develop children's critical evaluation skills so they are able to make an informed evaluation of online sites and services. Parents, teachers and others should continue to value children's expertise, but should also recognize that children need continued guidance in the use of the Internet.

Encourage more parental trust in children. While often naïve about threats to their privacy, children are fiercely protective of their privacy as it pertains to their parents. Thus, parents need to become more aware and obtain more information so that they can discuss the risks and give guidance, especially as their children grow older.

Improve levels of Internet safety awareness. Campaigns need to continue to ensure that the message gets across about the danger of chat rooms.

Maximize opportunities for participation and creativity. It might be useful to start channelling young people's involvement through links with music, fashion, animals, the environment, politics, etc.

"The gap [between] what children are actually doing and what their parents think they are doing is a lot larger than many people would have imagined. It is a gap we must try and close," says John Carr, Internet advisor to the Children's charity NCH and advisor to the UK Children Online survey.

It's 11 PM. Do you know which site or chat room your child is visiting? ■