From Instruction to Construction: Learning in the Information Age

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Today's landscape

Technology permeates all aspects of our lives and evolves at a pace that is at once terrifying and exciting. Internet attracts one million new net users a month. The number of components on a silicon chip doubles approximately every eighteen months while processing speed doubles every year. Computers themselves continue to shrink in size, replacing pencils and paper notebooks at many work sites (Craver, 1994; Pappas, 1996).

These developments are creating profound changes in the ways information is created, stored, and accessed. Wright (1993) cites the following examples:

- Graphic interfaces and pointing devices allow easier access to multiple forms of information.
- Online and electronic databases enable retrieval of finding tools and full text formats and graphics.
- Alternative input and output hardware and software provide touch screens, voice input and output, video and still graphics.
- Enhanced telecommunication capabilities make possible increasingly speedy and inexpensive access to remote databases.
- New software for information creation and manipulation yield a range of simple authoring systems and artificial intelligence programs.

For our students growing up in a techno-society, digital technology is part of the natural landscape. Youngsters use the Net to "manage their personal finances, check the scores of their favorite team, chat online, go to a virtual birthday party…their parting expression is 'email me'" (Tapscott, 1999, 8).

In short, the electronic evolution affects the way we create wealth, manage our economy, deliver our entertainment, run our government, make scientific discoveries, and meet environmental challenges. It also influences how we learn and teach.

In this reflective piece, the author maintains that student empowerment in an information-rich society is dependent on the convergence of learning principles and instructional practices that harness technology's power to extend and deepen learning. In forwarding this thesis, the author summarizes research findings and discusses their implications for rethinking traditional practice.

What research tells us

Studies conducted in the last decade have indicated that the effective application of technology offers many benefits, ranging from improvement in language skills development to promotion of student collaboration (Bialo & Sivin-Kachala, 1996). A sampling of the research follows.

- Language arts: technology enhanced students' language development, specifically in understanding the relationships among the parts of the English language, in reading comprehension, in sound discrimination and decoding in context, and in creating oral narratives (Mayfield-Stewart et al. 1994; Foster et al. 1994.).

- Critical thinking: Internet use produced significantly higher scores on measurements of information management, problem solving, communication, and presentation of ideas (Center for Applied Special Technology, 2001; Means & Olson, 1994).

- Motivation and self-confidence: use of electronic resources including telecommunication projects and multimedia productions, resulted in positive effects on student attitudes and student motivation (Borgman et al. 1995; Mendrinos, 1994).

- Individualized instruction: access to online resources created options for independent learning and strategies for individualizing classroom instruction, based on student needs. Use of these resources supported inquiry-based teaching and the inclusion of students with disabilities in mainstreamed classrooms (Kafai & Bates, 1997; Peck & Dorricott,1994; Woronov, 1994).

- Student collaboration: social interaction among students working together in electronic environments was shown to improve thinking skills, vocabulary development, and conversational competence (Morton, 1996). Recent studies have experimented with designing online learning tools that help students construct representations of their learning using collaborative learning processes. One such study (Suthers & Hundhausen, 2001) reported that alternative tools using text, graph and matrix formats all improved the ability of students to express their emerging knowledge in a collaborative, online medium.

Along with the benefits cited, other computer-related studies have more precisely defined obstacles faced by novice searchers. The inhibiting factors, which they identify, are not new to educators; they are familiar deficiencies magnified by the information glut that students face. According to Neuman (1995), the sophistication, complexity and specificity of information obtained through electronic resources frequently exceed the comprehension levels of the students as well as their needs. Some of the salient findings are summarized below.

- Domain knowledge: inadequate domain knowledge severely compromised the chance of a successful search experience because students were unable to pose appropriate research questions or select effective search terms. The students' level of background knowledge not only determined the types of resources they most needed but also the relevance of the information and sources they eventually located (Gross, 1997; Hirsch, 1997; Scott & Van Noord, 1996).

- Basic language and literacy skills: problems in reading comprehension, alphabetizing, spelling, and vocabulary resulted in students being unable to locate relevant sources or to skim and scan online texts for main ideas. Lacking these skills, students also encountered problems in selecting appropriate search terms and in generating alternative terms (Fidel, 1999; Nahl & Harada, 1996).

- Evaluative competence: young students were quick to assume that everything found on the Internet was correct; and they also failed to apply criteria such as accuracy or adequacy to the information located (Watson, 1998; Kafai & Bates, 1997).

- Information-handling skills: young information users did not always perceive searching as a set of clear expectations with a sequence of activities and strategies; and they had little notion of information searching as a nonlinear and linked process (Neuman, 1995). Consequently, they were unable to switch approaches when searching stalled (Fidel, 1999, Solomon, 1994). This ability to manage a "process of learning" was also deemed critical in studies that extended to workplace skills (Kuhlthau, 1999, 7). Lateral thinking processes, the ability to think in a relational way using databases and searching for information, were identified as essential for entry-level positions in many fields (Barner, 1996).

Pitts (1995) offered a grounded theory that synthesized the complex relationships among these various cognitive strands. Based on her observations of high school students engaged in research, she posited that their ability to conduct effective searches and to create knowledge from data were dependent on their competence in several critical areas: content area knowledge, technical proficiency in product creation, and skills in information searching and problem solving. Weaknesses in any one of these spheres affected student progress throughout the assignment and ultimately influenced the quality of the students' final presentation.

Implications for practice

A critical assumption underlying all of these studies is that computers in themselves do not automatically change the nature of teaching and learning. It is the way in which their use is integrated into classroom activity that produces educational benefits for students (Herring, 1999, Kosakowski, 2000). In short, the planning focus must be on the "individual educational needs of students and how educators meet those needs…rather than on what technology is or does" (National Education Association Special Committee on Educational Technology, 1989, 11).

To make our own professional sense of the growing body of research, we must examine these findings in the context of what needs to be learned and how learning occurs. Current teaching and learning beliefs support an interactive approach that relates new information to what is already known, that links abstractions to experience, and that evaluates ideas encountered in light of their relevance and utility (Thomas 1999). In this constructivist approach, there is a fundamental shift from instruction to construction and delivery. Learning is not simply assimilating knowledge transmitted by textbooks and instructors, but personally building and communicating knowledge. In this paradigm, students "must DO not simply LISTEN" (Tapscott, 1999, 9).

If we wish to create information-rich cultures that support high expectations, a spirit of independence, and a sense of community, the following essential questions must be addressed (Donham, 1998):

- How will technology allow students to do something of significance substantially better than they could otherwise?
- How will it empower them to function at higher cognitive levels?

To begin making the critical connections between learning principles and their implications for practice, we need to identify the characteristics of effective learning environments and to examine how technology contributes to the creation of such communities. Figure 1 juxtaposes selected attributes of a dynamic learning culture (Papert, 1996; Newman et al. 1995; Wright, 1993; Gardner, 1983; Bruner, 1962) with research findings in information technology.

Figure 1. Information technology: Attributes of a dynamic learning culture and their research-based implications.

Attributes of dynamic learning culture	Research-supported implications
• Learning is active and rigorous; it focuses on discovery and creative	• Online learning tools present new options for knowledge representations that help students to map concepts and ideas, and

construction.	to outline terms visually as well as abstractly. • Authoring tools encourage interactive modes of communication.
• Learning is nonlinear and multisensory.	• Hypermedia tools allow for divergent and nonsequential manipulation of information. • Electronic databases and indexes provide hierarchical and hyperlinked access to multiple forms of graphic, textual, multimedia information.
• Learning is collaborative and social.	• Collaborative online learning tools encourage participants to comment on one another’s notes, ask questions, and highlight what they find interesting. • Online networks expand opportunities to seek and share information with a global community. • Electronic publishing enables teams to generate a common electronic knowledge base.
• Learning is diversified.	• Electronic tools aid in customizing learning (e.g. online portfolios) and in accommodating different learning styles (e.g. authoring tools, application software with multiple learning options). • Networks and shared databases allow students to learn different things at the same time. They may also study separate aspects of a situation and share that knowledge with others. • Adaptive technologies allow students with disabilities to more fully engage in various learning experiences with their peers.
• Learning is problem-based, inquiry-driven.	• Electronic simulations allow for real-world applications. Emphasis is on questions and problem solving rather than simply answers. • Online access provides current links to human and electronic resources on timely issues throughout the world.

• Learning is process oriented.	• Information literacy skills focus on learning how to learn, on articulating information seeking process and problem solving strategies. • Evaluation software programs help students assess and evaluate their own progress, and retool and improve upon past practices.
• Learning is guided rather than directed.	• Teacher is less lecturer, more coach. Working with computers allows instructors to observe and to facilitate. There is more dialogue and mutual conversation than in teacher-controlled instruction.
• Learning is student-centered.	• Electronic tools and online access to information places decision-making more directly in the hands of learners. • Technology enhances opportunities for projects that are negotiated between student and instructor.
• Learning is a lifelong endeavor.	• Proficiency in information literacy skills is essential in both classroom and workplace. • Electronic access dissolves the artificial boundaries of the school day and the classroom. Learning is possible anywhere, anytime.

To summarize, schools that capitalize on computer technology recognize that information is fluid and easily manipulated through the cognitive tools of the search process. In “post modem schools” the emphasis shifts from “descriptive research,” where students merely move words around, to “explanatory research,” where there is “real digging to answer how and why things are related” (McKenzie, 1996).

The use of electronic and online applications enables users to visually and concretely view their searches and results on the screen. Instantaneously, the abstract becomes the concrete. “The reasoning powers of the intellect interact with the sense of touch, sight, and hearing for a holistic learning experience that involves the cognitive, affective, and sensorimotor domains” (Mendrinos, 1994, 13). In the electronic world, as learners are thinking, they are also doing.

Snapshots of emerging practices

What does student learning look like in such information literate communities? The literature abounds with promising illustrations of programs and projects that strive to integrate critical thinking and problem-solving skills in the new information landscape (e.g. CEO Forum on Education and Technology, Center for Applied Special Technology, ThinkQuest). In this section, the author briefly contributes several examples from two Hawaii-based projects: "Building Effective Teaching and Learning Partnerships" and "Hawaii Networked Learning Communities."

Partnerships project

The Partnerships Project, which was launched with an AASL/ABC CLIO leadership grant, brought together over twenty teams of K-12 teachers and library media specialists (Harada, 2001). Their collaboratively designed units focused on authentic, inquiry-driven learning experiences that included a range of electronic tools. Two of the elementary grade projects are briefly described here.

<u>Water quality.</u> At Mililani Waena Elementary, upper grade students joined with teams from neighboring schools to analyze the quality of water reserves in their community and how this affected their families. They formulated questions essential to their investigation, brainstormed possible online and print resources to consult, collected data samples on field visits to wells and local streams, devised electronic mind maps of data gathered, learned to create graphs and spreadsheets, and ultimately presented their group findings at an environmental summit sponsored by the Mililani Community Association. Throughout the process, students maintained logs reflecting their information seeking process.

<u>Assassin bug.</u> When a kindergarten student at Waikele Elementary discovered a strange bug on the school playground, his finding initiated a flurry of interest in his classroom. He and two classmates volunteered to find more information about the bug. They involved their teacher and the library media specialist and ultimately, they sent email to an entomologist at the University of Hawaii. Learning the identity of the bug was not sufficient for these youngsters; they wanted to know if it was dangerous and how they might share their information with the rest of the school. Through further email conversations with the entomologist, the kindergartners procured digital photographs as well as more information about the insect. Finally, they collaborated with their school technology coordinator, who helped them script and produce a two-minute video on their findings. Aired on the school's closed circuit television system, the team's effort inspired other youngsters in their class to embark on similar investigations of different insects. Finally, the class created a mind map of their collective information search process with the teacher's guidance.

Hawaii Networked Learning Communities

The Hawaii Networked Learning Communities project (HNLC), recently awarded a five-year, $6 million grant by the National Science Foundation, is a rural systemic initiative targeting improvement of science and mathematics education in disadvantaged and geographically isolated K-12 schools in the state. The enterprise focuses on inquiry-based, technology-enhanced learning. Examples of projects that are at the beginning stages of implementation are summarized below.

<u>Environmental mapping.</u> Schools on the Big Island (Hawaii) plan to use Geographic Information Systems (GIS), which are computer programs designed to analyze spatial data and to create an efficient method for investigating relationships in the environment. They will gather and examine data along the Hamakua coastline and build databases on area characteristics, species present, and patterns of use. Global Positioning Systems (GPS) will be used to supplement the data gathered through GIS by allowing students to more precisely locate data points of interest. GPS will also allow them to identify specific resources, such as endangered plants, with a high degree of accuracy. A wireless network will connect schools as they collaboratively manage data collection to address issues in their respective communities. Numerous research opportunities may emerge from this network. For example, experts can assist students at any time or location while schools develop a growing database on native plant species. Since digital photographs and GPS data will be continually entered over several years, students can observe emerging trends as they conduct research in ways never possible in a one-year course.

<u>Endangered plants.</u> The Hawaii Forestry and Communities Initiative has forged a partnership with Laupahoehoe High School to design and create an endangered species botanical garden, which will function as a “nurse forest” to regenerate native species in an understory for native dry land forest plants. Seeds and plants will then be distributed to the community for reforestation of the local area. As it grows, the nurse forest will be under-planted with other endangered and rare Hawaiian plants to form a viable plant and seed bank for the school and community. The project is envisioned as a cross-disciplinary endeavor. For example, bioagriculture classes will sample soil for composition, pH levels, and nutrients, and analyze this data through graphical and statistical means. Business classes will gain skills in math and accounting by monitoring the sale of plants and expand their entrepreneurial skills by developing a website for the project. English and social studies classes will research the plants for their cultural significance and design brochures to increase the public’s awareness of these endangered species.

<u>Resource management.</u> A K-12 school complex on the northeastern end of Oahu is presently engaged in a community study of land and sea restoration based on the Hawaiian concept of *ahupuaa.* In a unique system of resource management

in ancient Hawaii, the *ahupuaa* was a highly developed segment of land and ocean that was also an economic, political and cultural unit. Within each *ahupuaa*, people had to concentrate on renewable resources (solar energy, water, etc.) to sustain their social unit. In the present ecological project, students examine issues that integrate marine science with urban and agrarian concerns. They study how the environment has changed over time, how human activities have modified the ecosystem, and what society must do to promote its restoration. Electronic access to primary documents and to community experts will be critical in their investigation. Online chatrooms and interactive websites will be vital avenues for collaborative conversations and information documentation. In addition, the instructional team will be identifying various authoring tools that students might use to chart information and to communicate their findings.

Common threads

Collectively, these snapshots capture certain attributes that are crucial to our understanding and appreciation of what learning can be in an information-rich environment:

- Real-world problems and issues are fertile grounds for authentic learning opportunities.
- The inquiry process begins with the learner's genuine sense of curiosity; his or her questions lead to more questions.
- Deep learning requires access to and use of information from a global bank of resources.
- Knowledge construction is a social venture involving a collaborative community of learners of all ages bound together by a mutual interest or goal.
- Learning opportunities are negotiated efforts between students and instructors; the latter become engineers who shape rather than dictate these opportunities.
- A process approach to information searching and management must be incorporated into the total learning experience.
- When shaped around critical community issues, these experiences can foster a lifelong sense of social responsibility and stewardship.

The use of current and cutting edge technologies extends and enhances our capacity for building these dynamic learning communities. They allow for a collaborative construction of knowledge that is built over time. Contributions to this knowledge base can be generated from various locales and can engage diverse partners. These applications also introduce creative and divergent alternatives for manipulating data and for presenting information and knowledge to a truly global community.

Meeting our future

Mind-boggling advances in telepower, telecommunication networks, interactive media, smart technologies, and virtual reality applications proliferate our information landscape. Whether we are ready for it or not, our future is upon us. The solution is not merely to acquire more hardware and to expand our network infrastructures. The real challenge we face is to make thoughtful decisions about what is worth learning and how to empower students to achieve this learning.

McKenzie (1998) indicates that our goal should be to produce young people capable of navigating through a complex, often disorganized information network while making up their own minds about the important issues of their lives and their times. To do this, they must possess a "toolkit of thinking and problem-solving skills" to shape their own meaning making process.

Indeed learning in an information-rich environment engages all of us in the adventure of searching for connections. It invites us to explore and create new constructs. Ultimately, such learning entails forming bridges from data to new knowledge and insight.

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