

---

## Searching for Digital Libraries in Education: Why Computers Cannot Tell the Story

BERTRAM C. BRUCE AND KEVIN M. LEANDER

---

### ABSTRACT

THIS ARTICLE ARGUES FOR THE evaluation of digital libraries in schools by drawing upon situated observations, an exploration of educational goals, and a discussion of current technologies. As most of the research and development of digital libraries has been directed toward specialized workplace settings, the authors posit that an unrealized potential exists for the development of educational digital libraries, raising a number of current questions and challenges. First, the meanings and practices of information searching and information use are explored from the perspectives of teachers and students. The article next focuses upon contexts of library activity, emphasizing how physical and digital spaces carry their own meanings in relation to the school community and pedagogical practices. Further, these physical and digital spaces articulate and become the contexts of new hybrid practices and roles for educators and students alike.

### RETHINKING INFORMATION WORK AND LEARNING

In a library at a university laboratory high school, first-year students are searching for information about corn snakes to learn more about the snake living in their classroom terrarium. Part of their task is also to find a fitting name for the snake, something more creative than "Corny," and in so doing they are directed toward a variety of sources. Most of the eighteen students are seated at library tables and thumb through various texts—e.g., encyclopedias, reptile reference guides, books about

Bertram C. Bruce, Curriculum and Instruction Department, 387 Education Building, 1310 S. Sixth Street, University of Illinois at Urbana-Champaign, Champaign, IL 61820

Kevin M. Leander, 390 Education Building, 1310 S. Sixth Street, University of Illinois at Urbana-Champaign, Champaign, IL 61820

LIBRARY TRENDS, Vol. 45, No. 4, Spring 1997, pp. 746-770

© 1997 The Board of Trustees, University of Illinois at Urbana-Champaign

mythology. At one of the book tables, one boy remarks that he likes encyclopedias best among all of the available sources: "Here you get more of the kind of stuff you need for school projects."

Along the edge of the room, four of the students, all boys, are seated in pairs around two computers. A fifth boy, Matthew,\* has assumed a holding pattern behind one group, tapping his pencil on a chair back and peering over the shoulders in front of him. The two boys are using "Homework Helper," a commercial searching program and network of databases that permits students to access a given range of resources via an Internet connection, including newspapers, periodicals, academic journals, and reference texts (see Weinberger in this issue of *Library Trends*). In Homework Helper, students can enter a string of words, even an entire question, to search in an open text format. The boys enter the words "corn snake" and are directed to a number of references by the system, including, curiously, a passage from *King Lear*. In the passage (Act III, Sc. 7), Cornwall's servant turns on his master, who is treacherously poking out the aging Gloucester's eyes. As he draws to fight the servant, Cornwall's line is ironically "My villain!" Thus, the cross reference to corn snake in this search is at least double: "Corn" is an abbreviation for Cornwall, and snake, of course, is a synonym for villain.

At another computer in the back room, designated by the librarian for CD-ROM use, another student, Felix, also decides instead to use Homework Helper. Felix says that he has found Homework Helper to be the best resource for research: "You get the articles with the data and everything and you don't have to go looking around." Felix glances briefly at a few sources, and then his attention is drawn to Aztec snake poems published in an online copy of *Bilingual Review*. Felix reads several poems, selects three of them to print, and then returns to the main room and takes a seat at a book table.

While the students are seeking information, the teacher, like the librarian, moves about the room helping them find and use sources. From an outsider's perspective, the two move in parallel paths and interact with the students in similar ways. Fifteen minutes into the class period, the teacher moves to the computers to notify the students that their online time is up. In order to mediate what has thus far been unequal access to the technology by gender, she also announces that only girls may use the machines during the next round. Thus begins the era of digital library use in a school.

We have opened this discussion by taking you with us to a high school library, as we believe that the students' ordinary actions raise a plethora

\* All events in this article are factual. The names of the students are, however, pseudonyms.

of questions about what digital libraries do mean and could mean for education. This brief portrait of students working with resources suggests two critical vantage points for discussing digital libraries with and in their contexts of use. From the first vantage point, we focus upon information-related *activity* within school contexts. From the second we consider schooling *contexts* themselves as a lens for the information-related activity within them.

The two vantage points of activity-in-context and context-of-activity are intended to begin a dialogue on the meanings of digital libraries within schools. They presuppose that understanding human activity in situ (Chaiklin & Lave, 1996; Leont'ev, 1978; Wertsch, 1981), more or less mediated by tools, will yield us a clearer understanding of the meanings of the activity, the tools, and the context, than that provided through a focus on technological features alone. This presupposition is nearly a truism, yet it is implicitly denied in many discussions describing the search features of some new digital library tools. Before proceeding, we briefly outline the concept of a *situated evaluation* of technology.

#### DIGITAL LIBRARIES: THEIR REALIZATIONS IN CURRICULAR PRACTICES

As scholars have paid greater attention to technology in recent years (Bijker et al., 1987; Bromley, in press; Heidegger, 1977; Ihde, 1990; Latour, 1993), an odd consensus has emerged. The more we focus on technology, the less important specific technical characteristics appear and the more we begin to appreciate the ways technologies express ideologies and the ways they are embedded in daily practices. It soon becomes inescapable that to understand what a technology means we must understand how it is interpreted, employed, and even reconstructed through use.

This view has influenced evaluations of specific technological innovations. The concept of situated evaluation has been proposed (Bruce et al., 1993; Bruce & Rubin, 1993; Lave & Wenger, 1991) as an alternative to the usual assumption that a technology can be meaningfully defined outside of its associated practices. Situated evaluation assumes instead that a technology comes into being through its realizations in concrete situations. Thus, a crucial initial task for any researcher is to understand the various realizations of a technology before addressing the familiar questions about its effects. In the case of digital libraries, this means that we are unlikely to learn much about their meaning for education without better ethnographic accounts of what happens when they are actually used. This essay raises a number of questions and issues that ongoing situated evaluation might address.

Despite the potential of digital libraries for education, relatively little of the investment in digital libraries has been directed at public education. Instead, large corporations have become initial users and developers, creating special purpose libraries to serve their specific needs, usu-

ally tucked neatly away behind network firewalls that permit, at most, extremely limited and carefully controlled access to the public. And public funds have been devoted to creating digital libraries to serve small technical communities, such as space scientists, not for general-purpose libraries or education. This contrast suggests an unrealized potential and highlights our central concern: How do the practices, values, and contexts of schooling particularly shape the meanings of digital libraries for education? As we explore this question, we suspect at the outset that simple answers such as, “a digital library for children holds children’s books rather than technical articles” or “a digital library represents texts in electronic form and displays them on a screen” obscure, rather than reveal, how these new media may change education, or how they might be developed with educational goals.

## PART I: ACTIVITY IN CONTEXT

In our discussion of activity, two broad types are analyzed: information searching and information use. Several questions become relevant in a consideration of searching practices. How does the use of different tools, such as text-based encyclopedias or Homework Helper change the activity of searching and its meanings? How do such tools embed values and ideologies? How does their use construct the meanings not only of searching but of a school-based collection?

From information searching we turn to information use. How might pedagogical needs and purposes in using information be characterized? How do such intentions differ from those of adults in specialized workplace settings? In our example, for instance, what resource might we say would be most helpful in assisting a student to name a corn snake? What other purposes of the teacher and students are at work?

### *The Search for Information and Meaning*

Questions about searching in digital libraries inevitably evolve into questions about the nature of the searchers themselves. Thus, it is noteworthy that most current research, and consequently, dominant conceptions about digital libraries have been directed toward specialized workplace users—adults with shared academic, professional, or business work practices, ways of speaking, knowledge bases, and values. Currently, it is much less clear how to think about the nonspecialized user, an issue complicated by both the vast range of information needs and technical expertise of such an imagined group. As Finholt (1995) remarks: “Insights gained from observing space science faculty might indicate a set of design considerations wholly inappropriate for less advanced users. Second, when users don’t bring shared assumptions and expectations to a technology, who or what arbitrates among conflicting demands?” (p. 51).

A “generalized user” becomes all the more complex to envision as

we consider the special needs of schoolchildren at a range of developmental levels who often work together in highly heterogeneous groups rather than in self-selected specialized communities. If the digital library is intended to optimize resource access for these children as a "class" of users, then what sorts of assumptions should we make about them? Such assumptions, encoded into software, hardware, and network design, will construct at a minimum our vision of a student user's background knowledge, familiarity with categories, reading level, and school-based needs. Additionally, as digital library design may embed seemingly endless trails of hypertextual links, such trails presuppose users who can identify them, who recognize the political biases of particular references, and who understand critically the authority of given resources.

None of this is to say that digital libraries ought to mirror perfectly any given user's needs, knowledge, and quirks. Even thinking about corn snakes and Cornwall in the same breath, or especially corn snakes and Aztec poetry, can be a serendipitous interdisciplinary link rather than a distraction to the purposeful user or curriculum. Our goal is to continually turn the discussion back to students and educators as searchers, raising questions about who they are, what their practices and needs are, and what we expect them to know.

### *Searching in the School Library*

Perhaps one of the most common meanings for the term "digital libraries" in public school contexts today is the movement in many locations to automate or digitize library bibliographic records and hence to bring the entire circulation process online. Besides the obvious benefits to the librarian of this evolution for record keeping, inventory, and routine circulation work, what does this change mean for the searching practices of students within the library? At least some librarians strongly believe that creating a digital base of bibliographic records is an important advance for the searching student—the collection of texts is best accessed via a collection of bits and bytes. In this view, online forms of information are best understood not as competing with their hard-copy predecessors, or the collections to which they point: "rather, these new forms appear to reinvigorate the old, extending their useful social life, not ending it" (Brown & Duguid, 1996).

Some of the differences between card catalog and digital records are not evident on first glance: One must look beyond the mere technical translation of the bibliographic records to the redesign of the digital forms. MARC records permit topical searching that is more attuned to everyday language use than are the increasingly arcane Library of Congress subject headings and keyword searching of an entire record. Keyword searching of MARC records that include information well beyond that of their three-by-five ancestors, such as more extensive summaries or notes about

texts, can yield especially rich cross-referencing.

In fact, digital bibliographic records may well reverse student angst in locating information from the common moan "I can't find anything!" to the problem of not knowing how to limit available resources. One librarian illustrated this point for us by talking about a CD-ROM-based search system that references magazine article abstracts (EBSCO). The students continually struggle to focus their search topics. She half-jokingly points back to the technology as a guide telling them: "The machine is set on 250. If you get 250 on anything, you haven't sufficiently narrowed your search."

Simultaneously, paper-based card catalogs offer unappreciated advantages of their own. The haptic or physical presence aspects of information representations are only now being understood in an analytical way (Haas, 1996; Latour, 1986; Pimentel & Teixeira, 1993; Star, 1988, 1989), despite the common awareness that we often find things by cues such as, "having to bend over to reach it," "on the other side of that pillar," or "in the musty area of the reference room." Also, a physical card, unlike a digital record, permits a searcher to view both a single record and an entire collection and the relationship between them. The observation that different representation systems afford different ways of searching only highlights the need to consider the complex of user and technology when discussing how an information system works.

Further, institutional constraints need also be considered in making decisions about the uses of more or less technological forms, a problem that becomes much more evident in schooling than in workplace settings. For instance, given the current funding levels of school libraries, it could be said that card catalogs generally permit broader access than digital records. While several students can access a card catalog at any moment, even pulling out drawers and retreating to corners of the library, the number of students accessing digital records is limited to the availability of computer stations. Presently, it is not uncommon to find school libraries with only one or two such automated catalog stations, or to find librarians who wrestle with making their personal work computers publicly accessible.

Finally, as decisions are made about networking individual school libraries to one another, the meaning of searching within a particular library, as well as the distinctive identity of a library's collection comes into question. The negotiation of the value of individual identity and autonomy with the benefits of networking appears to be more acute in schools than within workplace settings, where accessibility to broad and exact resources is often the driving concern. An elementary school library that we visited, servicing a school with a highly diverse international student population, is one striking example of an identity deeply embedded in its student community. A significant part of the library's collec-

tion are several thousand books in over fifteen languages, including Korean, Hebrew, Bahasa Indonesian, and Urdu. What could be the potential benefits and risks of making this collection, so diverse from any other in its school district, a seamless part of a larger whole?

Or, as a related issue, how do the technical requirements and tasks of digitizing bibliographic records threaten the kinds of diversity that school libraries ought to celebrate? Will the technical capabilities and work practices constructed through networking drive not only catalog design but influence holdings as well? For instance, school libraries typically purchase commercial software to help them automate their bibliographic records, which will arrive preloaded with a select group of common book records and permit additional records to be added one at a time. Naturally, the library mentioned above will require extensive hand-entry of data: The staff estimates the task taking from two to five years, depending upon the availability of volunteers. Without such support, or without individuals' tireless efforts to preserve unique collections, might automated and seamless district, state, and national collections, for all they might offer in size, begin to encourage the evolution of the bland and regimented "McLibrary"?

#### *Technical Tools for Searching*

The ideal of a vast library collection that is also easy to use is often said to be realized within digital libraries. The two values embedded within this ideal—size and accessibility—and the ways in which they compete with one another, are a problem reflected through many more or less technical attempts to realize the ideal, such as the Library of Congress subject headings. Digital collections in schools can be imagined as falling at many points along the size continuum. Here we will briefly consider two extremes—the CD-ROM and the Internet—and their relevant searching practices and issues.

The CD-ROM encyclopedia has become a common enough tool in school libraries that we might even say it is the archetypal digital library in schools. In many cases, most of the digital information within a given school library is encoded on the disk or two that represent an encyclopedia set. Even relatively inexpensive home computers will often be packaged with CD-ROM encyclopedias, so some students experience the same version of digital libraries in both contexts. The encoding of an entire encyclopedia onto a compact disk, or onto the new DVD format, is a tangible example of the potential value of representing information in compact digital form. Moreover, the value of CD-ROMs resides in the fact that they are not simply technical translations—digital forms of a paper text—but rather transform their respective texts by permitting multimedia representations (stereo sound, video, enhanced graphical capabilities).

As CD-ROM encyclopedias represent a very small digital library, the difficulty of searching within them might be expected to be generally low. Further, it has been said that the practices involved in searching physical encyclopedias—selecting a particular page or two, skipping around—can be described as nondigital hypertextual practice, such that the movement from the use of such texts to their digital forms may be less abrupt than for some texts. Typically, the kinds of complaints that educators raise about CD-ROM encyclopedias have less to do with information searching and are more pointed toward the range of student practices in using them. For example, some students will use the CD-ROM encyclopedia as their only resource in library research, neglecting valuable books and periodicals around them. While the same student may have formerly relied on a shelf of text encyclopedias alone, this narrow range of searching is all the more evident when the student plants himself at a single machine while a queue forms behind him. On the one hand, this student might be engaging most of the school's latest technology, which we celebrate, and on the other hand, we attribute his painfully narrow use of sources to the technology.

One metaphor of the Internet might be that of an enormous tower of CD-ROMs, stretching somewhere into the clouds, packaged together with some communication tools. Yet such a vision misses the essential element that constructs the Internet as a digital library and sets it apart from stand-alone systems: the multiple ways and means through which sources are interconnected. From the resource perspective, the Internet might be seen as a wonderful classroom and digital library of the twenty-first century while, from the perspective of searching and information retrieval, it may well be, as Jacobson and Ignacio (1995) note, "the librarian's nightmare in terms of the lack of control over searching rules and expectations" (p. 21). Nilan (1995) reminds us that the navigation metaphors used for forays into cyberspace make sense only as long as adjacency within this "space" has some shared sense of meaning (p. 38). The Internet is difficult to search not simply because it is large, but because of how it has become large through loosely related, flexible self-organizing efforts distributed across the globe through a process with relatively little common structure. Consequently, browsers and searching tools, while attempting to move users in specific directions, continue to re-enact the flexible and divergent means of the Internet's ever-becoming. Nilan's (1995) critique of the immense size and interconnectivity of digital libraries, that "even the systems no longer know what is in the collection" (p. 38), is especially true of the Internet, where at no single moment can one isolate the development of "a system."

What meanings do such characteristics of the Internet have for the student searching on it? A range of viewpoints from students and accounts of their work by teachers and librarians have emerged. Some

students approach the Internet as The Digital Library, assuming “if it’s not here it’s not anywhere,” which can lead to the related notion that sources have value by virtue of having an electronic link. Educators are perhaps more anxious about students who imagine that the Internet is the only source worthy of searching as they are about those who resist using it. Such anxiety is fueled by public rhetoric around the Internet that constructs it as related to all that is ill about American education: It is an endless repository of mental junk food, digital Wonder Bread of the 1990s, mildly fortified. While we might praise the student who continually returns to a single shelf of tried and true texts as he produces papers across subject areas, we might shudder at the prospect of Matthew in our opening scenario—hovering about chair backs, seemingly at a loss within the library until the computer becomes available again. The fears of what he might find as he searches the Internet, and what he might not find, augment one another.

Unlike Matthew, other students are much more critical of the Internet as a resource or, in searching within it, find it out of synch with the kinds of resources typically required in school work. What do personal home pages about snakes, for instance, have to do with verified scientific knowledge of them? Further, students and educators alike find themselves historically at a juncture where notions about using Internet sources as authorities are still being formed and contested. Technologies that contribute to a particular world or other-world view are likely to be challenged. The confirmation of Galileo’s telescopic sightings of Jupiter’s moons, for instance, was largely dependent upon the development of agreed-upon practices of observation, and the concomitant development of a theory of telescopic vision by Kepler (Feyerabend, 1993). Similarly, sightings through the Internet are often uncertain, unstable, and hazy, needing verification across time through stabilized practices and theory development. In this new medium, an individual can produce a home page on the Internet with a visual rhetoric of authority that is just as compelling as the site of the Smithsonian Institution. The Internet tends to strip away physical artifacts of authority that we have come to depend upon, including the feel of hardcover books, the names of publishing companies, and the plain crisp lines on journal jackets.

#### *Mediating Technology Use and Technology as Mediator*

In the traditional library of texts, the librarian, aided by teachers and others, serves the role of mediator—selecting and arranging sources after a good deal of browsing and evaluating. While a loose and limited amount of arrangement is present on the Internet, centralized selection is virtually absent, so it could be expected that the user would enact a hybrid role of librarian and end-user: She both chooses the collection through browsing/surfing and then passes again to search through a

selected domain. How much of this work might we expect students to pull off? Perhaps we should not be too surprised if they perform one of these roles well—if they are good “surfers” but fail to put to use what they find, or conversely, if they readily put a chosen “collection” to use that far underestimates available resources. In order to mediate some of the difficulties in using the Internet, a range of resources and initiatives are being attempted. One way to consider such human and technical resources is that they enact part of the librarian’s role: pre-selecting an available collection and further organizing it according to a particular logic and values.

A range of such mediating tools exists, from introductory courses to search engines. In our introductory classroom scenario, the students are using a program named Homework Helper, which is not an Internet tool per se but functions through an Internet connection to provide access to both restricted and public domain databases. Homework Helper is set up with the following search categories: Arts & Entertainment, Interesting & Fun Items, Health & Medicine, Literature, Sports, Business, Politics & Government, History, and Science & Technology. A student may browse a topic with any combination of these subject categories. For example, one student we observed found that in his initial open-ended category search he was getting “a whole bunch of things that didn’t make any sense.” When he limited the subject field to “science,” the information he was after on corn snakes appeared more focused according to his needs.

In a very different type of mediative effort, many educators are beginning to construct their own home pages as shells or gateways to guide their students on the Internet for specific types of information searches. In one such large-scale project, researchers working with the University of Michigan Digital Libraries (UMDL) are developing a Science Teaching and Learning Project (<http://www.si.umich.edu/UMDL/>) that permits students to explore focused questions through the Internet. Through the course of their research, students have available online an overview of the inquiry process, a description of the desired end project, possible questions to pose, and valuable references. Thus the site is a hybrid of a range of pedagogical issues and requirements and a simplified map to the Internet, carving out a niche of questions to keep an investigation going with a preliminary set of resources.

The possibilities of mediative tools for the Internet are promising indeed. Not only are the needs obvious in order to better search the Internet as a meaningful digital library, but the tools themselves can effectively become embedded in the Internet, as described in the UMDL project, and contribute to a growing library of educational resources. At the same time, it is important to recognize that such tools, as they enact the roles of librarians and teachers, delimiting the scope of the Internet

and framing digital libraries within it, themselves encode educational values and perspectives. For instance, Homework Helper not only reflects but also helps to construct the roles of particular search categories. How does thinking about Business and Politics & Government as two distinct categories, for example, inform one's viewpoint? How will the practices of users and the technical tools encourage or discourage cross-disciplinary connections? Likewise, the UMDL Science Teaching and Learning Project does more than simply help students select resources; it also instantiates a particular approach to inquiry by scripting particular "driving questions," prompting with other questions, and determining the scope of a final project. In sum, any effort to make choices within the Internet's sea of resources inevitably makes evident a particular set of values. At a minimum, we should avoid the temptation to consider searches of any digital resource as a student exercise with value-free tools. Beyond that, we need to enter into dialogues with such tools, their histories, and their uses, in order to better understand the discourses that speak through them.

*From Searching to Utilization: Information as Pedagogical Tool*

At a working session of a recent national conference on digital libraries, one research group presented a model of the "life cycle" of information, which attempted to capture the idea that digital libraries are both repositories of resources and interactive communities (Borgman, 1996). The information life cycle depicts three broad phases of information use and life in a social system: creation, searching, and utilization. In the contexts of specialized workplace and academic libraries, a great deal of emphasis is put on information searching; there is a strong sense in which, once the librarian helps to locate specific information, his or her job is finished. This short curve of interest in information is also evident in digital library research and development work, largely sponsored and directed toward the needs of specialized professional communities. When such research does point to phases of information utilization and creation, it is often only to better consider how specific searching technologies might be made more effective. Additionally, the Information Life Cycle itself implies a particular view of information use that is characteristic of academic and workplace communities: Through activities of "retention" and "mining," information leads to the creation of more information, which can be searched and used by others in similar fashion (just as we are currently using the Information Life Cycle in this essay).

What can one say about information utilization in education, and what meaning does this have for the development and use of digital libraries? We would like to posit that, for educators, searching and locating precise information is often less significant than are the entire range of goals prompted once a resource becomes available. What body of

resources could we claim is necessary for children's digital libraries? While current and diverse resources are helpful and can contribute in significant ways to curriculum, in many cases one resource can be substituted for another to achieve an educational goal—the processes of use are far more significant than is the availability of a fixed data set.

Educators' goals may well include the "mining" and "retention" of resources, but they also want children to share, manipulate, play with, imitate, critique, oppose, and become increasingly curious about the resources they encounter. They want children to consider not only the resources themselves, but to look behind them and understand the processes of producing them, their intended audiences, and their possible meanings. Many educators value children learning certain intertextual connections between resources, but they also want them to develop their own categories, relationships, and understandings. Perhaps most importantly, they want children to develop the kinds of skills and understanding that would enable them to create resources of the kind they would find in digital libraries. Thus, children are potential authors for the library. This is a role few seriously imagine they can play with respect to traditional libraries.

Moreover, in many situations, educators encourage and cajole children to use digital resources not for what these sources may contain but for experiences with the technology itself. In a workplace setting, it would be very rare indeed to hear a supervisor say to one of her workers, "Jim, I'd like you to find some information on a CD-ROM today and then take a look at some Web pages. Any old information will do—I just want you to experience the process." However, formal and informal assignments not too unlike this are continually a part of the educational fabric, especially as diverse technological resources become more available and the need for training increases. In our opening scenario, for instance, the teacher's decision to limit computer use to fifteen minutes was not guided by a particular information-based vision of what the groups could find within these limits, but by the classroom objective of giving all of the students some experience with the technical resources.

Even from this brief discussion, the diverse and sometimes contradictory uses of information resources in education become evident. A significant challenge for digital library design and use in education will be to support the range of goals that are already alive in the classroom rather than simply making information a commodity. How can digital libraries and their use open up a child's inquiries, rather than bring them to closure? How might they enhance a child's critical acumen rather than dulling it? How might they assist in teaching students search processes rather than mystifying or suppressing this instruction?

Without asking what we value as we use digital libraries or any educational technologies, we risk failing to see their transformative potentials

and, at worst, we risk importing a contrary set of values that are embedded in such systems from their histories in other locations. For digital libraries, such an implicit value could be summarized as "complete information access leads to better education," just as it may lead to better academic research and workplace practices. However, the many teachers and librarians who have stacked unused textbooks and shrink-wrapped software packets in the corners of their rooms know that access is only a beginning.

*Information Use: Student Perspectives*

Student use of different technologies, whether they be textual encyclopedias or the Internet, will be informed by, and in turn will help construct, the kinds of values that retain significance in schooling. In our opening scenario, one of the boys remarks that he likes encyclopedias best for school projects as they are more likely to have "the kind of stuff you need." It would seem safe to say that encyclopedias also present information in the kind of clipped fact-by-fact form that school projects often encourage. As long as the teacher and the assignment follow the status quo, the encyclopedia is likely a smart choice by the boy according to his assessment of what to do in school—it follows both the form and content of what an eventual report should look like. Further, students are often pressed for time, either by school scheduling or procrastination, and will often find the most efficient ways of completing work, a quality that educators find both admirable and dismaying. The example illustrates how we cannot separate our vision of digital library design and use from the more basic issue of the kinds of work that educators assign and reward. In our experience, students are generally quick to understand not simply schoolwork as it is formally written, but the hidden texts of schooling—i.e., its implicit values such as grades, competition, or fashionable appearance—and they shape their actions and identities accordingly.

The stated and unstated values of an educational context will further intersect with the interests and needs of the student, as well as with availability and nature of technological tools she is using. For instance, a common complaint about CD-ROM encyclopedias among educators is that students can use them to plagiarize more easily for their school work. From this complaint, we could turn toward the moral weaknesses of today's youth, or we could turn instead toward the technology as encouraging unethical behavior. What if instead we were to take the entire event as an occasion where the school context, the assignment, the student, and the technology co-construct meanings together, and where the outcome is more or less predictable? Or how might the sociotechnical occasion be used by educators to teach ethical behavior for the many dilemmas—such as plagiarism—that students are likely to encounter in future workplace settings?

## PART II: CONTEXTS OF ACTIVITY

In this second major section, we focus more directly on context and consider how school library contexts may shape the activities within them. What meanings, and potentials, do both physical and digital spaces hold for pedagogical purposes? Further, how do such spaces merge? What does the movement from a physical corn snake to a cybersnake, from a science text to an e-mail communication, suggest about library hybrids in educational use?

### *The Articulation of Physical and Digital Space*

Shifting our focus from activity to context permits us to discuss the practices and roles of library users from a second vantage point, thereby addressing a few questions and raising new ones. Focusing first upon “library,” what purposes do school libraries serve as physical spaces? What is it about these physical spaces that we would hope to make digital? Next, is “digital” simply a modifier in the expression “digital library”? How do digital objects, and activities associated with them, open up our current meanings of “library” within educational contexts? How might the technology and its use potentially shape the school library such that it resembles other familiar and unfamiliar locations?

We begin with the assumption that thinking about digital libraries in schools as technical translations of physical spaces will likely be as unproductive as imagining them to be digital worlds entirely remade. In the final part of this section, we consider the possible meanings of digital libraries as hybrid physical/digital spaces. How do situated practices help us to understand these spaces as hybrids, and how do such hybrid spaces construct the work of students and educators? Are hybrid library spaces and uses primarily the result of a transitional period as we wait for more resources and technology?

### *School Library as Physical Space*

Pedagogical purposes for information are various and extend well beyond the retention or “mining” of information. Similarly, a very wide spectrum of purposes exist for the use of libraries as physical spaces, many of them having little or nothing to do with information-seeking at all (Reich & Weiser, 1993). School libraries, in particular, stake out a boundary where a broad array of activities take place, some of which are at cross-purposes with one another and/or at odds with the goals of the librarian. Here, for instance, is a hodgepodge of uses one can imagine:

- group work space
- chat room
- clearinghouse for school and community information
- rhetorical symbol of the academic strength of the school
- place to leave kids for teacher break
- parent volunteer center

- place to check e-mail
- recreation center—games such as jigsaw puzzles and chess
- sleeping and zoning-out space
- staff meeting space
- centralized location for technical equipment

Even from such a brief reflection, an observation we can make is that the physical library space has a central social importance for the school. It reflects, at different moments, what educators, librarians, and students alike construct the school to be. The library is a social hub not because it contains books, films, and newspapers, but because it is, in many cases, the only “public domain” space within the school building besides the hallways: Classroom space is territorially staked off and contains structured activities; cafeterias are often closed most of the school day; and gymnasiums, when they are not classrooms, self-select their basketball and volleyball players. Student lounges are infrequently a part of school buildings, and even teachers use the library as a lounge or as an available space to escape the teachers’ lounge. In sum, if the school were a home, the library would be the kitchen. The tools of the kitchen lead one to believe that its function is food preparation and consumption, but without a kitchen, many homes would lose their social center.

That the library is thoroughly woven into the social, rhetorical, and activity fabrics of the school is not a surprising revelation but becomes significant as we consider how such a relationship contrasts with the discussions and developments of digital libraries for specialized workplace settings. In many such settings, such as scientific laboratories and offices, the “library” as a physical space may have little previous history and meaning. Such specialized libraries may be fully integrated into other work spaces, existing as shelves of books and journals within an office or, alternatively, detached from the social life of the work space—a brick building across campus that one visits on occasion, alone and anonymously.

When the social meanings and sense of attachment to place are relatively muted, translating such spaces and uses to entirely digital realms seems unproblematic. But, in school libraries, the shock of such translation cannot be ignored. What extant purposes and goals of school libraries should be provided for within computerized forms? Should we seek for digital analogs to purposes such as “rhetorical symbol,” “place to leave kids,” and “zoning out space”? Some of these already are being shaped. Computer-based games, for instance, often fulfill and construct a recreational meaning of libraries, and school Web pages may be gradually assuming some of the rhetorical import that libraries have carried. Some researchers have begun to consider the situational uses and needs of public libraries (e.g., Reich & Weiser, 1993): “We believe that the networked library should strive to provide the following functions for community

identity: distinctive 'places,' geographically local networked meeting rooms, and a physical community presence." For school libraries, might important activities and functions of identity be best served through technical progress or physical spatial arrangements?

Another way to pose these questions is to wonder what difference it would make to simply distribute the school library, to de-centralize it and re-create it as a network of classroom computer stations. Kahle (1991) has proposed such a distribution of public libraries into "reading rooms" using the analogy of the transformation from centralized banking to ATM use. In schools, how would such a distribution not only change library use but the entire school community?

### *School Library as Digital Space*

While part of the evolution of resources from physical to digital forms may be best described in terms such as "translation" or "adaptation," digital environments also provide for resource forms to be present that are completely new (Nurnberg et al., 1995). The presence of such resources or objects within libraries effects a merging of libraries as institutional spaces with other institutions. For example, in Illinois there is currently a project underway which will link some 100 schools with statewide museums. Using the World Wide Web, students will be able to view artistic, historical, and scientific displays within these museums from school classrooms and libraries. In another case, through a collaborative effort of several departments at the University of Illinois, students in grades 2-12 have become involved in Project Mayday/ChickScope (<http://vizlab.beckman.uiuc.edu/chickscope/>). The project has permitted them to interactively access and manipulate a magnetic resonance imaging (MRI) microscope through the World Wide Web in order to observe the development of a chick embryo inside an egg. This manipulation has been accompanied by other WWW information-gathering work by the students, such as reading written information and viewing video clips of embryonic development (Bruce et al., in press).

As the resources in both of these examples appear less and less like information and more like "objects," their typified home locations remind us less of libraries. Museums in the first case, and scientific laboratories in the second, appear to merge with library collections. We would not argue that observing a museum online, or practicing in a virtual laboratory, is identical to being in their corresponding physical versions. Quite the contrary, as these locations and practices also merge with information and communication technologies, they must be reassessed and understood in new terms. Our point is to highlight the ways in which digital library use permits students to move beyond the confines of what we have come to understand as library borders, and to carry out activities that would be radically out of place within shelved rooms of books. Further, if

the hybridization of institutional spaces accompanies the evolution of resources, then we might expect this trend to continue or possibly accelerate as new and immature types of data change more rapidly than do physical, more familiar forms (Nurnberg, 1995).

Even more significant than the diverse objects digital technologies may import into schools are the processes permitted through them. For example, in ChickScope, students were able not only to observe the developing embryos through specialized equipment, they could also share their questions with the scientists and other children through online discussion groups. This mixture of information gathering with extended dialogue is perhaps one of the most exciting potentials of educational digital libraries. Through sharing interpretations, impressions, and local information, students are able to contribute to communities of inquiry that extend beyond their classrooms. What we may see in this case is a digitized extension of the "chat room" function of the physical library—students socializing with one another. We may also see, however, students not simply gathering information within libraries but challenging, comparing, and contributing to this information, becoming not simply information "surfers" but also "servers" (Levin, 1995). Such activity has great potential for motivating students, for engaging them and their ideas with broad and diverse audiences, and for helping them to understand the processes of knowledge construction and negotiation of meaning.

Student work, including stories, reports, and artwork, is often a part of physical school libraries, yet seldom is such work archived along with the permanent collection, nor does it represent dialogues with the creators of the collections' "authorized" texts. In digital libraries, such authorization and dialogue is possible. Such responses are valuable as single verbal expressions but also for the ways in which these may encourage ongoing interpretations and understandings: "People can see someone else express doubts that perhaps they felt no one else shared or were unwilling to voice. Questions that have been asked and answered remain for later readers to understand, without anyone needing to go over the same ground again" (Brown & Duguid, 1996).

Much has been written about electronic communities and whether they exist, what they are like, and how they differ from traditional understandings of community (see Bruce & Rubin, 1993; Handa, 1990; Hawisher & Moran, 1993). While the availability of information and communication technologies together may permit students to participate in such communities and their dialogues, it is perhaps too early to know what we might expect of these sociotechnical groupings. Brown and Duguid (1996) write of the significance of an "imagined community"—a community that exists on "too large a scale to be known in any other way." Participation in such an imagined community through technology, or lack of it, may

shape students' impressions of being inside or outside of what it means to be educated in our country. A fascinating function of technology and community building that Carroll discusses is the construction of a digital history within the Blacksburg Electronic Village, a community network with several components. The BEV HistoryBase contains "e-mail, old Web-pages, design documents, audio recordings of BEV pioneers, NBC Nightly News video clips, and so forth" (Carroll, 1995, p. 6; <<http://history.bev.net/bevhist/>>). The BEV HistoryBase development group has worked to shape the network such that normal functions of community information sharing and communication became automatically archived in the HistoryBase. The approach "reconceives the community network itself as a community working memory, one of whose functions is to consolidate current activities into shared memories" (Carroll, 1995, p. 7).

A school we have visited has also been working, on a smaller scale, to build a digital record of student multimedia projects that functions as a cultural history. The projects, including performances, papers, slides, music, and video, were developed for the Chicago Metro History Fair and National History Day competitions. Although there was a long-standing tradition in the school of participating in these events, there had previously been little record of past projects other than scattered materials, difficult to organize and even more difficult to review. Recently, librarians have begun to archive the projects on an interactive CD-ROM electronic index using Macromedia Director and other software. This creation of a "community working memory" of projects, a digital library of student creations, benefits students searching for past models, and the publication has also prompted more students to become engaged in the history fair and competition.

### *School Library as Hybrid Space*

Recently, major efforts have been devoted to developing digital spaces that duplicate, manipulate, or imaginatively depart from physical spaces and permit users to move through them, whether they be Egyptian pyramids or models of DNA (Dede et al., 1996; Foreman et al., 1996; Pimentel & Teixeira, 1993; Psotka, 1994; Roussos et al., 1996). Even virtual classrooms are being developed, such as NetLearningPlace, a project underway at the National Center for Supercomputing Applications (NCSA). The manner in which virtual reality is often discussed is through what we might call a rhetoric of technological replacement—i.e., the electric light replaces the oil lamp, the automobile replaces the horse, the virtual classroom replaces the physical classroom. Such rhetoric distorts the many ways in which newer technologies embed former technologies and social practices within them as well as the ways in which older and newer technologies and practices continue to coexist alongside one another and shape one another. The QWERTY keyboard, developed to slow the speed

of typists and thus keep the early mechanical typewriters from jamming, is an oft-cited example of such co-existence (Wertsch, 1991). As we type this article on portable PowerBooks and e-mail drafts to one another, the QWERTY keyboard still inhabits our machines and practices. In this section we will discuss some of the ways in which digital libraries in schools may be considered as hybrid spaces, with hybrid practices, roles, and communities enacted within them. While it is productive to consider the particular physical realities and technical possibilities of digital libraries, we will begin to suggest here some of the problems and issues that emerge as the digital and physical merge, blend, and reshape one another.

Revisiting the class that we portrayed in our introduction provides a telling example. Later in the class period, one girl, Caroline, used the Internet at a computer station, initiating her search by entering the word "snake." One of the sources listed was the *Massachusetts Guide to Snakes*, which she selected, and by quickly moving within this online guide, soon found herself pondering images and attempting to answer questions to help her identify a snake: "Is our snake cross-banded or blotched? Is the head small and oval? With round pupils, no pits?" Caroline began to pose these questions to the teacher, who decided to retrieve the snake from the classroom upstairs. After the teacher left, one of the authors (Kevin) asked Caroline if she was trying to identify the snake. She responded, "I know what it is—I'm just trying to see if they have it in here." Only minutes later, when the teacher returned with the three foot corn snake draped in her arms, Caroline had moved out of the *Massachusetts Guide to Snakes* and onto another online resource.

This brief account indicates some of the many ways in which information work in schools implicates the hybrids of digital and non-digital spaces, practices, and roles. Caroline approaches the computer in order to seek out information about an actual corn snake in her science classroom upstairs. Soon, the computer takes the information-seeking role, asking Caroline questions and showing her pictures of snakes produced several states away. Caroline reports that her interest in the resource at this point is no longer to get information, but simply to verify if her local knowledge of a snake is recorded in a more distant resource. There is a sense in which Caroline's activity at this point is like finding one's own picture in a yearbook—it is an identification not of unknown information about the snake but of its belonging with other snakes. Have the distant authorities on snakes included what is important to her and the class locally? When Caroline asks for help, she asks the teacher, who serves as a kind of librarian, but must move out of the library to get the information needed embodied in the actual corn snake. After the teacher runs up and down the stairs and imports the real snake into the physical library space, Caroline has moved off into another part of digital space, where examining the physical snake has no particular purpose.

The movement of library use from Caroline, to the computer, to virtual snakes, to the teacher, to the classroom, to real snakes, and back to other digital snake information is suggestive of the complexity of the merging of physical and digital spaces in school libraries. Moreover, while the first part of this movement curve appears to be a productive border-crossing motivated by an inquiry that Caroline has taken up from the digital text, the second part of the curve suggests the kinds of problems that might emerge from such transfer. Caroline is able to skip much more quickly through digital space than the teacher is able to dash physically and retrieve the snake, such that in the end the two environments, practices, and individuals are out of synch with one another.

This account also points to some of the ways in which movements between physical and digital spaces shape the roles of librarians, teachers, and students. For example, whose questions are at work within the scenario? Is Caroline engaging in inquiry, is the computer, or are both at work together? In many ways, the teacher works here as a librarian, helping the students find information and work with the technology. But do librarians fetch snakes from classrooms? Finally, we might speculate on what may have assumed an authoritative source for Caroline should the interaction have continued: the distant virtual snake guide, produced by another community, or the local community and its understandings of the corn snake?

One possible response to this discussion of hybrid practices, spaces, and communities is to claim that these effects are simply a temporary artifact of an evolution, an in-between state, a fish with stubby legs. Such a response participates in a rhetoric of replacement: As soon as technology has advanced far enough and is widely accessible enough, digital libraries will have realized their full meaning and use. Another response is to raise questions about what it is that both the digital and the physical represent to us, and what it is that we value in both. On a simple technological scale, some have pointed to the notion that, while digital environments are better for browsing, physical mediums lend themselves more to reading. On a more theoretical level, Brown and Duguid (1996) have posited that, while we value the transience and speed offered by information and communication technologies, we also value the delay and fixity offered by traditional forms. Further, new technologies are developed and used in ways that purposely permit both ways of working—hybrids between past practices and current possibilities:

While everyone can benefit from technology capable of overcoming separations of space and time and the convergence of producer and consumer, it seems people are beginning to appreciate how important these distinctions can be. New technologies help us to transcend burdensome barriers of space and time. But, in part through the improvisations of users, the same technologies are also valued for their ability to reinject both space and time into communica-

tion. (Brown & Duguid, 1996)

In education, when and how do we value rapid and exploratory movement, instant communication, expanded community identity, and dialogic texts? When and how do we value deliberate and pensive movement, delayed communication, local attachment to community, and stable authorized texts? Ultimately, further observations and analyses of hybrid products and uses of technology can lead us beyond thinking of technology as a grand march toward progress and toward reflections of how such mixed products and uses embed values that are at once significant and conflicting—i.e., our ideological dilemmas (Billig et al., 1988). Such reflections will help us understand not only how we might change libraries, but how it is that our historical and present visions enter into dialogue with one another (Gadamer, 1994).

#### CURRENT CONTRASTS AND FUTURE CHALLENGES

In this discussion of digital libraries, we have hoped to move current debates concerning technical capabilities, design, and even “usability” toward a consideration of the practices, contexts, and values of those who work and learn in our schools. We have not attempted to represent a coherent or complete picture of educational activities and contexts; rather, we believe it is most significant to realize their extreme variety. Further, it seems critical to realize that educators and students will engage in activities and hold beliefs of a dilemmatic nature (Billig et al., 1988), and that any technological development in the schools will enter into dialogue with such tensions.

In discussing physical and digital “spaces” that students and educators move within and between, we have argued that a replacement rhetoric—exchanging the physical for the digital—is too simplistic a treatment of the development of digital libraries. Both physical and digital terrains present problems and offer distinct advantages for searching and resource work; moreover, our practices within both contexts may reflect and reconstruct significantly embedded contrasting ways of choosing to experience the world, such as through delay and fixity on the one hand and transience and speed on the other (Brown & Duguid, 1996). Perhaps more important are the many ways in which these spaces and associated practices become hybrid forms. We have posited that such hybridization is especially acute within schools, where students and educators have diverse intentions, have limited access to technological resources, and participate in a culture deeply embedded in physical space. We hope, further, that the notion of the hybrid is productive not only as a descriptor of physical/digital contexts but also as a metaphor of how we might consider the purposes and practices of schooling as they dialogue with various technological forms, often developed in distant contexts and inhabited with sharply contrasting histories and ideologies.

Most of the research and development of digital libraries has been applied to workplace settings and to specialized technical communities. Several striking images emerge through the juxtaposition of workplace settings with schools: While workplace users are more concerned with the exact contents of a digital collection, educators are more invested in its diverse uses; while workplace users share common discourses and goals, those of students and teachers are widely heterogeneous; and while physical library space is more at the periphery of workplace settings, it often assumes a central social role within schools. These and other contrasts

Table 1. Contrasts of Workplace Settings and Schools

	<i>Workplace Settings</i>	<i>Schools</i>
<b>Activity in Context</b>		
Information Searching	comprehensive collection favored for specialized user--shared discourses, background knowledge, access rights, and values help guide search processes	nature of "complete" collection is indeterminate--highly heterogenous users with little common background; searching processes are one pedagogical goal
Information Use	goals of information use often centralized within organization--resources served focused and typically stable goals, such as the production of knowledge, products, and services	goals of resource use in constant negotiation among educators, students, assignments, available technologies, etc.--widely variable goals, including technological experience, inquiry, interpretation, and authorship
<b>Contexts of Activity</b>		
Physical	library may or may not exist as physical space within setting; marginal social significance	community identity co-constructed with physical space; high social significance
Digital	new types of resources available, including virtual "objects" and interactive media--extension of local professional community	new types of resources available, including virtual "objects" and interactive media--participation in various communities made possible
Hybrid	merging of physical and digital spaces likely, depending upon work practices	frequent merging of digital and physical spaces due to shifting goals, available resources, and flexible participant roles

are represented in more detail in Table 1.

Our hope is that the contrasts represented in Table 1 will help raise an awareness of the need for continued research and resource allocation for the development of digital libraries for education. In such development, educators must form and follow their own agendas, while at the same time recognizing that their work is constructed from a history with contexts and goals sharply different from their own. Raymond Williams (1974), in his insightful analysis of the development of the forms and institutions of television, contrasts a theory of technological determinism with the meanings of the cultural forms that a technical device assumes. Williams argues that television has clearly not adopted the forms it has taken today by technical necessity, but through the struggle of more or less powerful historical, social, and institutional pressures:

Original intention corresponds with the known or desired practices of a particular social group, and the pace and scale of development will be radically affected by that group's specific intentions and its relative strengths. Yet at many subsequent stages other social groups, sometimes with other intentions or at least with different scales of priority, will adopt and develop the technology, often with different purposes and effects. Further, there will be in many cases unforeseen uses and unforeseen effects which are again a real qualification of the original intention. (p. 129)

While Williams posits that the cultural forms of technology evolve through "continually renewable social action and struggle," he argues that "institutions and social policies which get established early on—often *ad hoc* and piecemeal in a confused and seemingly marginal area—have extraordinary persistence into later periods" (p. 147). Such may well be the case in the development of digital libraries. The contemporary institutional and cultural shaping of their meanings at this early stage will likely have significant and lasting effects on their development in years to come. Ultimately, the issues that have been raised invoke our greater social investments and raise significant questions: how educators will be involved in this critical time of development, whether their involvements will be socially and institutionally supported, and how such work will be communicated to the more established and supported corporate traditions.

Finally, this discussion would be harmfully misleading if we were to construct the notion that "schools" exist as a homogeneous group. We would not want to portray the school context of our introduction, for example, as typical, or conversely, as some sort of desirable model. While we argue that the purposes, practices, and availability of resources within schools contrast in important ways with those of workplace settings, we recognize at the same time that there are significant disparities of access to technical resources among different schools—which are beyond the scope of this article to discuss—but are crucial for a more complete vision of possible futures. Further, readily visible and invisible equity is-

sues are also embedded within individual school contexts. Note, for instance, the obviously male-gendered orientations and assertiveness toward the computers in our opening portrait which the teacher attempts to mediate. Less visibly, some of the students in the school library may have continual access to digital libraries in their homes through personal computer systems and modems, while others may be experiencing them first-hand among their classmates, or in facing this equity gap, choosing not to. Clearly, as research and critical analyses of technological equity in education move forward (Bromley & Apple, in press; Commeyras et al., 1996), such work must inform situated evaluation, where not only how technology is used, but who is able to use it, articulates its meanings and social value.

## REFERENCES

- Bijker, W. E.; Hughes, T. P.; & Pinch, T. J. (Eds.). (1987). *The social construction of technological systems: New directions in the sociology and history of technology*. Cambridge, MA: MIT Press.
- Billig, M.; Condor, S.; Edwards, D.; Gane, M.; Middleton, D.; & Radley, A. (1988). *Ideological dilemmas*. Newbury Park, CA: Sage.
- Borgman, C. (Chair). (1996). *Social aspects of digital libraries workshop: Preliminary workshop report* [WWW document]. Available from: <<http://www.gslis.ucla.edu/DL/>>.
- Bromley, H. (in press). The social chicken and the technological egg: Educational computing and the technology/society divide. *Educational Theory*, 47(1), 51-65.
- Bromley, H., & Apple, M. (Eds.). (in press). *Education/technology/power: Computing as a social practice*.
- Brown, J. S., & Duguid, P. (1996). The social life of documents. *first monday*, 1(1) [Online serial]. Available from: <<http://www.firstmonday.dk/issues/issue1/index.html>>.
- Bruce, B. C.; Carragher, B. O.; Damon, B. M.; Dawson, M. J.; Eurell, J. A.; Gregory, D. D.; Lauterbur, P. C.; Marjanovic, M. M.; Mason-Fossum, B.; Morris, H. D.; Potter, C. S.; & Thakkar, U. (in press). ChickScope: An interactive MRI classroom curriculum innovation for K-12. Manuscript submitted to *Computers and Education Journal*, 9/30/96.
- Bruce, B. C.; Peyton, J. K.; & Batson, T. W. (Eds.). (1993). *Networked-based classrooms: Promises and realities*. New York: Cambridge University Press.
- Bruce, B. C., & Rubin, A. D. (1993). *Electronic quills: A situated evaluation of using computers for writing in classrooms*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Carroll, J. M. (1995). How to avoid designing digital libraries: A scenario-based approach. *Sigois Bulletin*, 16(2), 5-7.
- Chaiklin, S., & Lave, J. (Eds.). (1996). *Understanding practice: Perspectives on activity and context*. New York: Cambridge University Press.
- Commeyras, M.; Orellana, M. F.; Bruce, B. C.; & Neilsen, L. (1996). What do feminist theories have to offer literacy, education, and research? *Reading Research Quarterly*, 31(4), 458-468.
- Dede, C.; Salzman, M. C.; & Loftin, R. B. (1996). ScienceSpace: Virtual realities for learning complex and abstract scientific concepts. In *Proceedings of IEEE virtual reality annual international symposium* (pp. 246-253). New York: IEEE Press.
- Feyerabend, P. (1993). *Against method* (3d ed.). New York: Verso.
- Finholt, T. A. (1995). Evaluation of electronic work: Research on collaboratories at the University of Michigan. *Sigois Bulletin*, 16(2), 49-51.
- Foreman, N.; Wilson, P.; & Stanton, D. (1996). Can virtual experience assist the development of spatial awareness? *Ability: The Journal of the British Computer Society Disability Group*, 15, 20-21.
- Gadamer, H. (1994). *Truth and method* (2d rev. ed.) (J. W. Weinsheimer & D. G. Marshall, Rev. & Trans.). New York: Continuum.

- Haas, C. (1996). *Writing technology: Studies on the materiality of literacy*. Mahwah, NJ: L. Erlbaum Associates.
- Handa, C. (Ed.). (1990). *Computers and community: Teaching composition in the twenty-first century*. Portsmouth, NH: Boynton/Cook, Heineman.
- Hawisher, G. E., & Moran, C. (1993). Electronic mail and the writing instructor. *College English*, 6(55), 627-643.
- Heidegger, M. (1977). The question concerning technology. In W. Lovitt (Trans.), *The question concerning technology, and other essays*. New York: Garland.
- Ihde, D. (1990). *Technology and the lifeworld: From garden to earth*. Bloomington, IN: Indiana University Press.
- Jacobson, F. F., & Ignacio, E. (1995). Evaluating digital libraries in the context of learning and teaching. *Sigoi's Bulletin*, 16(2), 21-22.
- Kahle, B. (1991). *Electronic publishing and public libraries* [WWW document]. Available from: <<http://www.village.virginia.edu/readings/kahle.txt>>.
- Latour, B. (1986). Visualization and cognition: Thinking with eyes and hands. In *Knowledge and society: Studies in the sociology of culture, past and present*, Vol. 6 (pp. 1-40). JAI Press.
- Latour, B. (1988). Drawing things together. In M. Lynch & S. Woolgar (Eds.), *Representation in scientific practice* (pp. 19-68). Cambridge, MA: MIT Press.
- Latour, B. (1993). *We have never been modern* (C. Porter, Trans.). Cambridge, MA: Harvard University Press.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, England: Cambridge University Press.
- Leont'ev, A. N. (1978). *Activity, consciousness, and personality* (M. J. Hall, Trans.). New Jersey: Prentice Hall.
- Levin, J. (1995). *Learning resource server* [WWW document]. Available from: <<http://www.ed.uiuc.edu/lrs/>>.
- Nilan, M. S. (1995). Ease of user navigation through digital information spaces. *Sigoi's Bulletin*, 16(2), 38-39.
- Nürnberg, P. J.; Furuta, R.; Leggett, J. J.; Marshall, C. C.; & Shipman, F. M., III. (1995). *Digital libraries: Issues and architectures*. Paper presented at the Second Annual Conference on the Theory and Practice of Digital Libraries, Austin, Texas [WWW document]. Available from: <<http://csdl.tamu.edu/DL95/>>.
- Pimentel, K., & Teixeira, K. (1993). *Virtual reality: Through the new looking glass*. New York: McGraw-Hill.
- Potka, J. (1994). Immersive tutoring systems: Virtual reality and education and training [WWW document]. Available from: <<http://198.97.199.60/its.html>>.
- Reich, V., & Weiser, M. (1993). *Libraries are more than information: Situational aspects of electronic libraries* [WWW document]. Available from: <<http://www.ubiq.com/hypertext/weiser/SituationalAspectsofElectronicLibraries.html>>.
- Roussos, M.; Leigh, J.; Johnson, A.; Vasilakis, C.; & Moher, T. (1996). *Approaches to constructive K-12 playtime/education in the CAVE: The N.I.C.E. project*. Unpublished paper presented at the NCSA VR and Education Program for Educators, July 16.
- Star, L. S. (1988). Introduction: Special issue on sociology of science and technology. *Social Problems*, 35(3), 197-205.
- Star, L. S. (1989). Institutional ecology, "translations" and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science*, 19(3), 387-420.
- Wertsch, J. V. (1981). *The concept of activity in Soviet psychology*. Armonk, NY: M. E. Sharpe.
- Wertsch, J. V. (1991). *Voices of the mind: A sociocultural approach to mediated action*. Cambridge, MA: Harvard University Press.
- Williams, R. (1974). *Television: Technology and cultural form*. New York: Schocken Books.