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ABSTRACT

Important and dramatic changes are occurring in five broad areas of literacy: the movement toward universal literacy; the changing demands for literacy in the workplace; the creation of a global society; how languages are evolving; and the way literacy practices are becoming immersed in new technologies. Future literacy needs will demand a continual rethinking of the purposes of schooling in relation to society, and in particular, an ongoing critical analysis of the way in which access to societal resources change in response to changing conceptions of literacy. The traditional separations among disciplines of study and types of work are in question, implying the need for more integrated conceptions of literacy and literacy development. The globalization of trade, work, language, history, and politics is reconstituting and expanding conceptions of literacy. Literacy is changing along with changes in languages, especially English. Literacy is inextricable from conceptions of and uses of information and communication technologies, including both new technologies like the Internet and older ones like the book. Whether changes in literacy will lead to greater access to information and tools, to more liberatory education, to multicultural understanding, to improved social relations, or to a more democratic society remains to be seen. (Contains 52 references, 5 notes, and a table listing 14 Internet resources.) (RS)

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November 1995

Center for the Study of Reading

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TWENTY-FIRST CENTURY LITERACY

The word "literacy" never seems to stand still. It makes its appearance in the discourses of history as well as those of comparative linguistics. It shows up in debates about economics and literature. It mediates interdisciplinary conversations among scholars from history, sociology, anthropology, political science, linguistics, education, literature (Keller-Cohen, 1994). It also participates in public debates about schooling, employment, and public values. As it appears in these areas, it assumes different guises and enacts different purposes. The diverse array of meanings and connotations for literacy that we see today provides perverse evidence for Humpty Dumpty's view that a word can mean "just what [we] choose it to mean--neither more nor less."

If we want to survey current issues in literacy, we soon find that any attempt at a fixed definition of literacy quickly becomes enmeshed in larger discussions of language, thought, society, culture, and values. And the situation becomes hopeless when we begin to examine future directions for literacy. Accordingly, in this paper I will make some working assumptions to keep the word within some bounds, even if it cannot be fully reigned in. One is that literacy means control over discourses that use and communicate complex forms of knowledge. Since there are many such discourses, there can be multiple literacies. A second assumption is that literacy is so embedded in our daily practices that it can scarcely be conceived as an activity separate from any of them. A third assumption is that the changing technologies of literacy provide a window into literacy practices, both because they are the tools through which literacy is enacted and because their construction reveals our basic conceptions of literacy.

There are five broad areas in which important and dramatic changes are occurring today. The first concerns *democracy*, and in particular, the movement toward universal literacy; the second relates to *work*, with a focus on changing demands for literacy in the workplace; the third takes us to *social relations*, and especially, the creation of a global society; the fourth concerns *language*, and how our language(s) are evolving; and the fifth is *technology*, with an emphasis on the way our literacy practices are becoming immersed in new technologies. Although the areas of democracy, work, social relations, language, and technology cover much ground, I hope to show that trends in these areas exhibit some convergence. Given the many facets of literacy that pervade our lives, these speculations will necessarily be abbreviated, and like all such imaginings, their naiveté will become most apparent as reality actually unfolds.

The Movement Toward Universal Literacy

Politically, the "literacy crisis," and its cousins, the crises in mathematics and science education, the breakdown of the schools, and so on, serve as a bulwark for arguments from conservative, middle of the road, and liberal perspectives. Some see lack of literacy skills as an explanation for inequities in the distribution of social power and social goods. They argue that illiteracy accounts for high unemployment or underemployment, and by implication for poverty, crime, substance abuse, and other social ills. After all, they say, if a person doesn't have the skills demanded by today's employers, how can he or she expect to be hired for a good job?

Others see the lack of opportunities to develop literacy as itself an example of social injustice--an effect rather than a cause of inequities. Class inequities in access to jobs, health care, and housing outside of the school system are reflected in the literacy problems within the schools. One striking example is that 40 years after the Brown v. Board of Education decision, which said that separate schooling by race was inherently unequal, many school systems are still effectively segregated, and many of the rest still practice segregation and unequal distribution of resources within schools and individual classrooms.

Interestingly, commentators from all parts of the political spectrum seem to agree that literacy is not what it should be, and that the schools are much to blame. This universal dismal view persists in good economic times and bad. But major long-term trends run counter to it. For example, high school graduation rates in the U.S. at the turn of the century were around 6-8%; by the 1920s they had reached 17-29%; and by the 1940s had climbed to 51-59%. For the last 25 years they have remained steady at or above 80%, and are among the highest in the world (Green, 1994; Marable, 1993; White, 1987). Another indicator is the purchase of books and magazines. Annual sales of books are at an all-time high in the U.S., over $9 billion, and growing (McGuire, 1995); sales of academic journals amount to over $1.5 billion (Leslie, 1994). There are also many indications that more people use more reading and writing in their work and leisure than ever before and that the rates are rising despite television (Newman, 1991), so-called inadequate schools, and the alleged breakdown of the social order.

This is not to say that schools should not be improved. There are many schools with inadequate resources and appalling physical conditions. Nearly all could improve their record at providing excellent learning opportunities for all children. And, perhaps most importantly, what was good education a generation ago may not prove even adequate for tomorrow.

Meanwhile, the students in our schools are changing. More children remain in school, and for most, the consequences of not succeeding may be more severe than ever before. Whether illiteracy causes social distress or is itself a consequence of that distress, it is certainly true that they are closely linked, especially in the inner cities. We are also more aware than ever of the diverse cultures that children bring to school. Although it is debatable how much the degree of cultural diversity within schools has increased compared to earlier periods in our history, there is no doubt that accommodating diversity, and using it as a resource, rather than seeing it only as a problem, is a major concern for future literacy developments.

Developments in technology pose interesting challenges for universal literacy. In principle, new technologies could provide access to texts and tools for writing for all people throughout the world. For example, Project Gutenberg, the On-Line Book Initiative, the Oxford Text Archive, and related projects are making thousands of documents—the complete works of Shakespeare, Beethoven's Fifth Symphony (audio), Supreme Court decisions, the Apollo lunar landing (video)—available through the Internet (Fisher, 1993; Harris, 1994; Krol, 1992; LaQuey, 1994).

Using a $1000 computer system, a classroom anywhere in the world can have access to a library utterly unaffordable in conventional print form, one containing resources available to no single library in the world, unless, of course, that library has an equivalent computer system. Moreover, democracy movements in many countries are using fax machines and electronic mail in lieu of printing presses hitherto out of reach.

But despite these promising new tools, there are many indications that inequities in access to new technologies are enormous and increasing rapidly. Because of the rapid evolution of information and communication technologies, society is increasingly stratified by "generations" of technology. Even within a single community, people living physically side by side live within different ages of cyberspace. In a country in which the top one percent of families have more wealth than the bottom 90 percent (Schreibman, 1994), there is little reason to think that information technology resources will be equitably distributed.

This is evident already with computer use in schools. Wealthier countries and wealthier schools within those countries have greater access to new technologies. Moreover, students in wealthier schools more often use computers for open-ended learning activities, such as writing, art, science simulations, and global communication. In contrast, students in other settings, such as inner-city schools, may experience only drill on basic skills (Boruta et al., 1983). Even within a single classroom there is evidence that the distribution of access to computer tools and information "follows the well-trodden battle-lines of social

conflict" (Foucault, 1972, p. 227). Students with computers at home typically become classroom experts, receiving special attention and opportunities. In contrast, students in "remedial programs" fall farther behind when they miss the introduction to the computer because of being pulled out of class (Michaels, Cazden, & Bruce, 1985). There are also large gender inequities. Only about 15% of Internet users are female, and across wide ranges of computer use in schools, girls have less involvement with new technologies than do boys. The metaphors of use are predominately male, and often, explicitly anti-female (Bryson & de Castell, in press; Kramarae & Kramer, 1995; Taylor, Kramarae, & Ebben, 1993). Thus, technological innovations often exacerbate underlying inequities, despite the optimistic visions of change. If "knowledge work" becomes the norm, does that mean that everyone will develop advanced literacy skills?

A similar situation is occurring with the "information highway." This was originally conceived as auguring a new age of two-way communication to empower people of all classes by giving them both information and voice in decision making. But the highway sometimes looks more like a shopping mall or a high-tech medium for the one-way delivery of information. Will the global hypertext mean that for the first time in history all people will have convenient access to all forms of encoded knowledge and the associated empowerment associated? Or, does it mean that access to knowledge and the use of information tools will become prized commodities, controlled and regimented according to one's wealth and social position?

Will 21st-century literacy be "the practice of freedom" as Freire says, or will it become commoditized and stratified as never before? Worse still, will the same information tools be used to monitor and control, to imprison us within the technology? As Crawford (1994) says, "The road to freedom via a two-way Information Highway may turn into a one-way Surveillance Street, used to condition people's thoughts and control their behavior." Video surveillance is now so ubiquitous that we may be on television more than we watch it (Patton, 1994).

Events are occurring so rapidly that it is difficult to answer any of these questions. But it is equally clear that discussions of literacy cannot ignore them, because literacy itself cannot be separated from the larger social and political issues. If we are to influence the direction of change, we need to understand the processes better and to grapple directly with the underlying contexts in which decisions are being made. For students of today, universal literacy is dependent upon democratic schooling, and simultaneously, a prerequisite for future democracy.

Changing Demands for Literacy in the Workplace

In the workplace, literacy is assuming an ever more central role. This is a new kind of literacy, which entails not only basic reading and writing, but the ability to use reading and writing to solve problems and to communicate complex information. It is necessary for "knowledge work," the new modal form of work: "By the end of this century knowledge workers will make up a third or more of the work force in the United States--as large a proportion as manufacturing workers ever made up, except in wartime" (Drucker, 1994, p. 62).

The shift to knowledge work can be seen in more than just a changing proportion of workers who do it. One indication that has a direct bearing on literacy concerns is that there are now tens of thousands of scholarly journals; American libraries alone subscribe to 50,000 of them (Leslie, 1994). No person could ever read all the journals now published, or even all the journals in a major discipline. Sociology, for example, may have 3,000 or more journals. While the need for careful reading does not go away, the sheer mass of writing implies the desperate need for other important reading skills, such as learning how to find materials, how to judge them critically, and how to select from among the abundance available. But, a glance at most published curricular materials shows that they operate on a very

different model, one in which students are presented with a few pre-selected texts, and never given an option to decide that the texts they have been assigned are inappropriate for their needs.

The number of scholarly journals marks more than an issue of quantity: Each of these journals reflects a specialized discourse, a way of interpreting the world and making meaning. Control over that discourse means a kind of literacy (Gee, 1990). There are thus thousands of variants in the meanings of literacy reflected in these scholarly journals alone. Moreover, many of these journals correspond to different modes of (knowledge) work, to different ways that literacy is employed in work practices: The way a chemical engineer represents meaning, relates language to the world, and communicates with others is not the same as the way a banker does. The proliferation of these multiple literacies is a special challenge for 21st-century literacy development.

Along with the profusion of literacies, reflecting the extreme specialization of work, there is a trend toward instability in the characterizations of these literacies. Universities are increasingly finding that the traditional categorization of the disciplines bears little relation to the use of disciplinary knowledge in the workplace. In many work settings, workers must find ways to solve problems in conditions that change rapidly and require collaboration among people with diverse sources of knowledge. This puts a premium on the ability to communicate across differences and to work cooperatively. As an example, faculty in an electrical engineering department have discovered that their graduates rarely need to know how to solve a classic EE problem, which rarely arises neatly in a practical setting. Instead, they need to know how to talk with a physician with whom they are collaborating on a space shuttle project, or with a marketing person about the design of a new piece of software. Ironically, hyper-specialization and the technologizing of work has highlighted more than ever the need for the classic liberal arts of tolerance, communication, understanding the perspectives of others, consideration of values, and holistic understanding.

Workers of the 21st century will need to acquire and apply formal knowledge in ways very different from those required in agricultural, manufacturing, and service jobs of the past. They will not be able to get all the information they need from one text or manual, but will need to integrate knowledge from multiple sources, most likely obtained through electronic resources such as the World Wide Web, or its successors. There will be too much information for any given task, just the opposite of what has been true in the past. Workers will need to cope with an abundance of information, to select critically, considering the source and the relation to what else is known. None of these skills is new, but the 21st-century workplace foregrounds them in a way never before known.

Workers will also need to collaborate with others, and to use both oral and written language to facilitate that collaboration. Working together, always an important skill, will become ever more important. The forms of these collaborations may also change. New technologies are creating new social matrices. Many people are already collaborating with others through the Internet and through the use of groupware (multi-user software). In the future, more and more people may collaborate through virtual reality environments. Can we say that a MUD (multi-user dungeons), MOO (MUD object-oriented), or MUSH (multi-user shared hallucination) is only a game, and not a forerunner of the workplace of tomorrow? Even today, there are text-based virtual reality communities. For example, teachers of composition now meet regularly in Media-MOO[1] to discuss issues related to writing pedagogy.[2]

These tools are already changing education. For example, the Teaching Teleapprentices Project (Levin, Waugh, Brown, & Clift, 1994) is a nationally known effort exploring the use of Internet resources, the World Wide Web, and electronic mail by children, teachers, future teachers, and university scientists. In this project, electronic communication links children with student teachers, student teachers with their cooperating teachers, university education professors, and scientists. In related projects, experienced teachers engage in reflection on their own practice through an electronic mail network (e.g., DiMauro & Gal, 1994).

Schools have been moderately effective at teaching students to solve problems that are presented in a familiar, well-structured way. But increasingly, computers are able to solve these well-structured problems, leaving totally untouched the more complex problems that must be addressed in order to get a job done (Spiro, Feltovich, Jacobson, & Coulson, 1992). To take an extreme case, the entire traditional mathematics curriculum from grades 1 through 8 has been dubbed the "$5 curriculum," because most of what was taught could be done by a $5 calculator. But the harder problems of estimating and approximating, selecting which operations are appropriate, relating results to the tasks at hand, evaluating a solution and so on, are left untouched. Other major elements of the standard curriculum, from spelling to history dates need to be rethought in the context of new tools. In the workplace of the future, workers will need to be able to find problems, not just solve them, that is, to look at a complex situation and turn it into a structured problem that has a solution.

Perhaps most importantly, the ability to learn will be not just a helpful, but a necessary condition of productive work. Lifelong learning will become an integral part of more and more careers. Already, spending on industrial training rivals that of the entire public school system. This is but one tangible realization of the adage that schooling is but a beginning to life. In the future workplace, education will be a continuing focus throughout.

The Creation of a Global Society

Whether we accept the dismal or the optimistic view of literacy trends, many questions arise regarding what may happen next. We now live in a global society, one that is changing every day. Increasingly, the work we do, the products we use, and the people we interact with represent languages and cultures throughout the world. What sorts of literacy are needed in this new world? Just as the last remnants of geography are being swept out of schools and universities, it seems suddenly to matter how the rest of the world lives and thinks. Just as high schools, colleges, and universities have all but eliminated foreign language requirements, we begin to understand why it is important to be able to communicate in more than one language and to understand different ways of thinking. Just as we proudly put forth new standards for learning in various subject areas, we begin to see ways in which the traditional concept of the disciplines--English, mathematics, science, social studies--may be inadequate for future needs. New standards documents all call for more integration of learning across the disciplines, yet they and the corresponding new forms of assessment reify the separateness of the traditional categories. Our plans for literacy development seem to be solving yesterday's problems, while the world is changing around us.

The global society is now a permanent part of our workplaces, schools and neighborhoods. As large corporations become ever more multinational, people may find themselves working with people who inhabit other cultures and speak other languages. For example: A man who has lived his entire life within ten miles of his birthplace in Texas suddenly finds his company has been purchased by a company based in Germany. He now needs to learn to speak German, to travel to Germany, and to work with people from Germany. He soon finds, of course, that many of the people he meets in Germany are from yet a third country. Similarly, his children attend a school with children from all parts of the world, something he did not experience. All these changes are but the beginning of a new kind of world in which we will all soon be living at the border.

Among other changes we need to consider is the emergence of the World Wide Web (December & Randall, 1994; Krol, 1992). The Web is a vast sea of documents, including text, graphics, tables of numbers, software, video, and audio. These materials are all linked in a global hypertext (Barrett, 1989). Any information resource that can be put into digital form can be made available to computer users throughout the world. These documents are easily accessible. They are also linked together so that they become in effect, not just a library, but a single gigantic book, what has been called the "docuverse," or the universe of knowledge.

The World Wide Web was started in 1991 at the European Laboratory for Particle Physics (CERN) in Geneva. As the Web began to take shape, easy-to-use interface programs, or web browsers, began to appear, including Mosaic, Netscape, MacWeb, and Lynx. The category of browsers has already become a basic application comparable to word processors, spreadsheets, electronic mail, or graphics programs. Today, users can access an amazing array of resources from the home, classroom, or workplace (see Table 1). Many people believe that it will become the dominant medium for information exchange in the 21st century.

[Insert Table 1 about here.]

The growth in use of the Web is already difficult to comprehend. There are now over 10,000 Web servers, or computers that are dedicated to sharing databases of information and are accessible through the Web. Available information resources and information traffic on the Web are already measured in terabytes--trillions of characters, or the equivalent of millions of 500-page books. In the single month of December, 1994, the Web accounted for 16% of the information traffic on the NSF backbone, or 3.5 terabytes of information.[3] That is comparable to 3.5 million books or 7 million large images. This is an underestimate of total use, because much network traffic is hidden behind corporate "firewalls" that prevent access by the public. It is more noteworthy that the use of the Web is growing at a rate of 1% daily, or 3000% annually (Gray, 1994). This has happened without the involvement of commercial on-line services, such as Prodigy, telecommunications companies, such as MCI, and software makers, such as Microsoft, all of which are now making substantial investments in expansion of Web access.

The Web is but a tangible manifestation of the interconnectedness of human knowledge and social practices. Once upon a time, it may have made sense to imagine that we could be satisfied knowing only the history of our region or country, or that our literature was a complete and uncontaminated collection of all the texts we needed to know. In that time, we might also have believed that our religion, politics, social values, language, work, and daily practices could go on without concern for what others "far away" might do. But today, it is evident that everything we know and do is but a small thread in a larger social fabric that we cannot escape, even if we wished to do so. For these reasons, debates about multiculturalism often play out in an imagined past. We worry about whether there will be enough time for Shakespeare if students read Confucius, or whether they should study African history. These are questions about what would happen if we made changes to the curriculum. But the changes *have already occurred.*

This is because the meaning of school practices can never be separated from the social life around those practices. Ideas that once were at the periphery of educated discourse are now at the center, not by anyone's choice, not by a desire for inclusiveness, not to prepare students for a changing world, but because the world itself is not the same. Formal education, of course, influences educated discourse, but it does not determine it. Confucius, and Mao Tse-tung, are effectively part of the curriculum now, because no study of history, economics, language, politics, and technology can ignore the history of one billion people. Similarly, African history is part of history. It always was; only in that isolated past could some people imagine that it was not part of their history.

Reader-response criticism provides a case in point. Classic theories (Fish, 1980; Rosenblatt, 1978) of reader response have emphasized the situated nature of response in contrast to the primacy of the text. In so doing, these theories opened the door to a reinterpretation of canonical texts, and to a rethinking of the canon, curriculum, literature, and the act of reading itself. Ironically, though, early reader response theorizing was centered within a Eurocentric and male-dominated domain. Thus, the radical potential of the theories was concealed by the fact that the text examples, the readers, and the interpretive communities were all drawn from one small corner of the social fabric. More recently, response studies have encompassed much more of the fabric. Studies of gender and reading have brought about a reconceptualization of the meaning of many texts, and of the very processes of reading

and writing (Flynn, 1988; Flynn, & Schweickart, 1986). Similarly, textual and response studies of African literature have expanded our vision, not only by adding new texts to consider, but by revealing a richness in language and in the processes of meaning-making (Gates, 1988).

The emergence of the global society means that literacy is changing. It encompasses more than it ever has before in terms of both content and form. More kinds of knowledge are accessible and more kinds are needed. Discussions of literacy will have to expand to reflect this globalization.

Evolution of Language

Literacy is intimately bound up with language. We need to learn a language before we can become literate users of it, and we use literacy as a way to learn other things through language. This connection is so obvious that we often overlook its significance. Often, it is only when reading a text from long ago, such as *Beowulf*, that we become aware of the complex relations between literacy and language. But the evolution of languages will undoubtedly make us much more aware of these relations.

One factor contributing to increased awareness is the changing composition of public school classrooms. In many schools today, students bring not just one or two, but dozens of different languages from their homes. There is a commitment, which our country has not always had, to educate students whose home language is Black English or other than English. This means that the notion of progressing from oral to written language has assumed a significant new meaning for literacy development. We must consider that students learn not simply a new form for the same language (an oversimplification, even in that case), but new forms and new languages at the same time.

Meanwhile, the definition of English is itself changing. English has always been a paradigm case of an amalgamated language, with roots in Anglo-Saxon and Latin, through French. Speech in English is filled with words from Spanish, Italian, and German, as well as Native American, Scandinavian, Asian, and African languages. But as global communication expands at an exponential pace and as people travel and move from country to country, the mix of language influences on English will undoubtedly increase.

To add to the changes, people all over the world are learning English. There are probably more speakers of English in China today (for most, it is a second or third language), than there are in the U.S. There has emerged the concept of world Englishes, to describe the variety of versions of English spoken throughout the world. As more people speak English, and use it in trade, science, and cultural exchange, it will inevitably expand and change to accommodate their experiences and linguistic backgrounds.

Thus, English is no longer the language we thought it was last year, and it will be a different one next year. This cannot but have profound implications for our idea of literacy in English and for promoting literacy development. At the same time, other languages are also changing, many in the same ways that English is changing, and others in very different directions. Hundreds of other languages are dying out as the last speakers themselves die or assimilate into dominant cultures. Many of these languages are being preserved, but only in a curatorial sense, on videotapes and in dictionaries and folklore collections. They thus become accessible for study by everyone at the same time as they become spoken by no one.

In addition, advances in science and technology are producing new words every day. The ways we describe phenomena in areas of health, communication, transportation, and more, change as we develop new procedures and new understandings. People who market products add to the changes as they strive to develop ever new ways of distinguishing their products or services.

Other technological influences shape the things we can do with language. For example, multimedia systems integrate oral and written language in a hybrid that is causing us to rethink the great

dichotomies between oral and literate culture. Also, the ability to manipulate fonts, formats, colors, and other presentational aspects of texts may fundamentally change how we conceive of writing. And as everyone who has used electronic mail soon becomes aware, dialects of electronic communication are proliferating, with characteristic abbreviations ("BTW" for "by the way") and emoticons (such as the smiling face: :-)).

The nature of publishing is also undergoing rapid changes. Writers are now producing hypermedia texts. For example, Art Spiegelman, the author of *Maus*, and now, *The Complete Maus*, on CD-ROM, says, "I think CD-ROMs imply a new kind of narrative. . . . Instead of just moving through time, all of a sudden stories now move through space, so that architecture becomes the reigning metaphor" (Voyager, 1994). Academic publishing is also assuming new forms. There are hundreds of electronic journals listed by the Association of Research Libraries, and much scholarly work is now conducted via e-mail and on-line conferences. These trends may fundamentally alter basic aspects of scholarship, including copyright laws, academic tenure, concepts of collaboration, the nature of research, and the definition of publishing (Burbules & Bruce, 1994; Cherniak, Davis, & Deegan, 1993).

Meanwhile, e-mail has become a normal part of the daily literacy practice of many people. The Electronic Messaging Association estimates that in 1993 there were 16 million e-mail users in the business sector alone. These users sent the equivalent of 10,000 manuscripts the length (not the quality) of *War and Peace*, every day that year (Leslie, 1993). This indicates two things. First, literacy, at least in the form of reading and writing electronic mail, is active and growing rapidly. The advent of computer technology has certainly not eliminated the practice of literacy. Second, the amount of text in the world is astounding. If 10,000 *War and Peace*-length manuscripts appear every day, the problem may no longer be to finish reading the book, but to find it in the first place. As discussed above, the skills of finding, selecting, and evaluating have become more critical than ever before.

These changes raise many questions, with few easy answers: What is English, and what will it become? How do our notions of English literature or of the literatures of the world change in light of the changes in languages and the forms we use for communicating? How do our ideas of the relations between language and inquiry or language and collaboration have to change? What do these changes mean for our conceptions for literacy? What are the implications for the teaching of writing and reading?

Immersive Technologies

There has also been an evolution in our views of information and communication technologies for literacy development. If we consider stages in this evolution, we can see not only different kinds of hardware and software, but also different visions of literacy and of ourselves. We are now changing our conceptions of literacy further because of our immersion in new forms of knowing and communicating.

In the beginning, we constructed computer technology as an exotic, and marginal, method for teaching, We did this by designing hardware and software to function as an automated tutor for skills and concepts. But we also constructed it by the way we conceived it, as a tool for systematically teaching concepts, presenting problems to solve, and administering drills and practice lessons. In the process, we also constructed our own teaching role as analogous to that of the tutors we designed.

Later, in a second stage, we saw that cybertechnology represents information in new ways. The computer as medium, or cybermedia, became our construction. At that time we saw how the computer could offer greater user choice in the presentation of materials, could integrate the text, audio, and video media provided through separate components (slide projectors, audio tapes, television, etc.) in earlier technologies.

Then, in a third stage, we began to understand the information tool potential of cybertechnology; we saw that it provides new tools for learning. Thus, we talked about word processing, desktop publishing, finding information in databases, making graphs and pictures, and performing calculations in the course of problem solving.

As students began to use cybertools in their own ways for learning, the communication aspect became more central. We moved to a fourth stage, one in which we saw that cybertechnology could do more than represent someone else's information; it could also be a way to share one's own ideas (Bruce & Rubin, 1993). This led naturally to the view that cybertechnology could create new environments for communication and learning, in which students working together could share their processes of learning. Moreover, they could be connected to a world beyond the classroom, that included experts in every field (Levin, Riel, Miyake, & Cohen, 1987). That view in turn begins to connect with a vision of the augmented human mind and of collective thought whose reach extends beyond that of any individual.

Today, we are entering a fifth stage, in which we merge, for better or worse, with our own inventions. The extent to which this has happened can be seen in the realm of science fiction. Producers of television shows and movies are now using techniques to create science fiction that only a short while ago were the content of sci-fi. Tools such as morphing, in which images are transformed, computer animation, virtual reality, and robotics are current technologies used to create the illusion of a future world in which these very technologies will come into being. Recently, for example, the creator of the television show *X-Files* used the sci-fi technique of an on-line forum with fans to discuss the direction of the show (Kim, 1994). As Ray Bradbury says, "Science fiction itself has remained the same. We have caught up to it . . . . We are a science-fiction generation." Science fiction screenwriter Ron Shusett (*Alien*, *Total Recall*) echoes this sentiment: "We can't think far enough ahead anymore." (Both quotes from Kim, 1994).

Consider just a few other examples. There is now a commercial music accompaniment system called *Vivace*, which plays along with a student learning an instrument. Like the old *Music Minus One* records, the system plays the other parts of a composition, but it does so responsively. If the student wants to play *allegro*, so will *Vivace*. Moreover, it changes the tempo when he does, *ritards* when he does, and waits when he falters on a note. It learns characteristics of his style and accommodates appropriately at the next practice session. And even its degree of responsiveness can be adjusted, anywhere from the rigidity of a metronome to a humanly-impossible total accommodation. Research is underway now on the effects of interacting with systems like this. It is not at all obvious what these will be, but the experience is completely unlike that of the (first-stage) tutor model. Instead of interacting with a device, the student somehow merges with it.

Multimedia software developments present other aspects of the changes underway (see Voyager, 1994). For example, a CD-ROM called *In the Deserts* (D. C. Heath, 1995) takes a student on a virtual field trip, starting with a 360-degree panorama of the Sonoran desert. She can click on a plant or animal to see an animation or video segment. Carrying along (a computer simulation of) a computer notebook, she can write about what she discovers and take photographs of anything she sees. She can also access multimedia texts to meet a Native American potter, a storyteller, a naturalist, or other children. Exploratory environments such as this create opportunities for integrated learning through immersion in another world.

Moving a step further, full virtual reality systems (Helsel, 1992; Helsel & Roth, 1991; Pantelidis, 1993; Pimentel & Teixeira, 1993) reveal in a tangible way our immersion in technology. Psotka (1994) suggests that virtual reality

> provides a fundamentally different mode of communication between computer and person, between symbolic form and mental representation; and between collaborators

> in conceptual worlds. VR replaces interaction with immersion; it replaces the desktop metaphor with a world metaphor; and it replaces direct manipulation with symbiosis. The magnitude of these changes needs to be experienced to be understood.

One of the most sophisticated VR systems is the CAVE (CAVE Automated Visualization Environment). It is a "virtual reality theater" in which several people can share a virtual reality experience, without the need for goggles.[4] It is a high-resolution 3-D visual image and audio environment, with correct perspective and stereo projections updated in real time, and images that move with and surround the immersed viewer(s). In one application within the CAVE, the participants feel that they have entered a computer screen saver program, with fish swimming all around them. They can drop pellets for the fish and watch them swim over to eat. One has the feeling of a fundamental shift from spectator to participant. Researchers are only beginning to explore the forms of learning that this technology might enable in areas of mathematics, astronomy, geography, physiology, history, and more.

One other example is an entire new industry, bioengineering. This field hardly existed a generation ago, but has been born of a combination of new technologies. First, there are technologies such as ultrasound, X-ray, EEG, EKG, electron microscopy, fiber optics, and magnetic resonance imaging that have provided new ways to see the human body and its inner workings. These imaging techniques are amplified by the use of laser discs to store images and high speed networks to distribute them. There are also new kinds of prosthetic devices, such as artificial knees, and new tools, such as microsurgery, for treating dysfunctions in the body. Finally, there are simulation and virtual reality systems to facilitate exploration of our newly constructed knowledge about the body. Together, these tools are creating an entirely new image of our physical existence, one in which we see ourselves through the technologies we have created, modify the functioning of our bodies through other technologies, and express our understanding through yet other technologies. We may celebrate this new world, fear it, or curse it, but what seems unavoidable is that we already inhabit it. We have redefined part of what it means to be human by establishing a symbiosis with new technologies.

Our discourse about technology, including great debates about whether it is good or bad for teaching, is built upon the myth that we can stand apart from technology. As Suchman (1988, p. 174) says, ". . . [We] are taught to view the political and the technological as separate spheres, the former having to do with values, ideology, power, and the like, the latter having to do with physical artifacts exempt from such vagaries of social life." Thus, we conceive a set of doors into alternate futures, reflecting a free choice among new technologies, and ask "whether" we should pass through.

What we fail to see is that we and our technologies constitute indivisible entities. We are already cyborgs in the sense defined by Haraway, part fiction, part social reality (1991, p. 149). Our technology part has been constructed out of our beliefs, values, and extant practices, and in turn, it has brought us through the door to the future. Thus, we are already operating within the future that we believe we must prepare ourselves for.

Cybertechnology is not something that some people will choose to adopt; it is already a part of our literacy practices regardless of what we do. One small example: In many libraries, it is not possible to find recent books in the (paper) card catalogue, because only the computer database is updated. I once tried to find the location of the *Scientific American* collection in the University of Illinois library. The computer told me "No Entries Found," because, as I learned later, it deletes "unimportant words" in a search request, words such as "the," "and," "of," and sadly for me, both "scientific" and "American." Since I could not believe that the university had no subscription to this magazine, I checked the obsolete card catalog, which had not been updated for ten years, and discovered that there were at least 14 collections of *Scientific American* on the campus. The choice was not whether to use the computer or traditional cards, but whether to use the computer to find a book or not find it at all.

Literacy Artifacts

Far off in the future, archaeologists interested in literacy might uncover artifacts representative of our literacy practices. Let us consider two artifacts they might find that would call forth contrasting images. The first artifact they might examine is the famous Rosetta Stone.[5] Because this slab had the same text in three scripts, it became a key to deciphering the previously cryptic Egyptian hieroglyphics. It had been preserved for over two thousand years, and was still readable. Moreover, it provided clues to reading other ancient texts that would enrich our understanding of our cultural past.

This famous tablet would evoke for future archaeologists the metaphor of "permanence." Archaeologists would think of ancient hieroglyphics or cuneiform preserved in stone for thousands of years; of monks laboriously copying sacred texts, preserving them for all time; or of a canon of received great literature, to be memorized, studied, and cherished. These thoughts would index the cultural assumptions we hold about connections between literacy and education—our beliefs that education is the process whereby new generations connect with prior human experience; that education is the "means of this social continuity of life" (Dewey, 1966, p. 2); and that literacy gives us access to the permanent record of social life.

The second artifact presents a contrasting image of literacy: There is no stone tablet, not even a book made of paper. Instead, there is a pattern in cyberspace, a string of bits, which could be portrayed on a video screen, printed out on bond paper, or sent through the air as spoken words. The text in this second artifact was constructed collaboratively, by people who lived in different parts of the world and spoke different languages. Individual document pieces are linked to each other and to myriad other texts in the worldwide web of knowledge. Many of these texts contain scripts, like those of the Rosetta Stone, but others have pictures, diagrams, music, voices, and full-motion video. It has holographic images of objects that could be explored from any perspective, with commentary by the creators of the objects and the critics.

This text, like other well-written texts, has a distinctive style, even a voice, that conveys meaning beyond the literal. As do the great classics, it calls for a deep connection between authors and readers, a stretching of horizons. But in contrast to the Rosetta Stone's evocation of history and permanence, this text points the archaeologists toward an image of literacy as a practice enmeshed in change. It suggests radically different ways of thinking and an altered conception of education.

The two artifacts also show the future scientists how our concepts of literacy were inextricable from the literacy technologies we created. The technologies shaped the sorts of literacy we practiced, and in turn, the technologies we created were a function of our evolving conceptions of literacy.

The aspect of change in literacy practices would not trouble the archaeologists; indeed, they would be seeking to understand how the changes in literacy that they knew had actually come about. For people of today the task is more difficult, because we do not know what the literacy artifacts of tomorrow will be. As is the case in many areas of change (Andrews, 1994; Malone, & Rockart, 1991), we will undoubtedly overestimate the short-term effects of current trends, while we underestimate their long-term impact. Nevertheless, the trends described above raise many questions we cannot afford to ignore regarding literacy development, how to promote it, what it means for schooling and life, and even what literacy is.

Whatever we say about literacy, it is not separable from democracy, work, social relations, language, or technology; instead, these are mutually-constituted practices. As we examine these areas, we see trends and counter-trends, major and minor themes, puzzles and contradictions. But there are some consistent, recurring ideas that may help make sense of all the complexity:

1. Future literacy needs will demand a continual rethinking of the purposes of schooling in relation to society, and in particular, an ongoing critical analysis of the way in which access to societal resources change in response to changing conceptions of literacy.

2. Literacy practices in the future may become highly collaborative enterprises, corresponding to an intensification of emphasis on coordination and communication. The traditional separations among disciplines of study and types of work are in question, implying the need for more integrated conceptions of literacy and literacy development.

3. The globalization of trade, work, language, history, and politics, is not an option, but a fact in the process of becoming ever more established and articulated. This is inevitably reconstituting and expanding our conceptions of literacy.

4. Literacy is changing along with changes in our languages.

5. Literacy is inextricable from our conceptions of and our uses of information and communication technologies, including both new technologies, like the Internet, and older ones, like the book. Questions of curriculum are not eliminated by the availability of new tools and greater access to resources, but rather are made much more vital than ever before.

There are basic questions we once thought we could answer, which need to be asked all over again, among them: What is literacy? What is learning? What is teaching? What does it mean to be human? The issue of who controls the development of literacy technologies and what values are applied in making decisions is critical, but almost entirely ignored in discussions of literacy.

It seems inevitable that dramatic changes will occur, have already occurred, in our literacy practices. But whether these changes will lead to a greater access to information and tools, to more liberatory education, to multicultural understanding, to improved social relations, or to a more democratic society remains to be seen. Many forces operate to prevent progressive changes, and we know well that technology alone cannot bring them about. If we are to achieve the possibilities that the new literacy holds, we must work to understand both what it is, and what it can be. There is much work to be done.

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[Note: Internet information for the references cited is listed below.]

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Footnotes

[1]At telnet://purple-crayon.media.mit.edu 8888/.

[2]The jargon of the cyber-age is incomprehensible to many, and it changes so rapidly that only an electronic dictionary is of much help in decoding it. I could turn this article into a glossary or I could completely omit technical terms; neither choice seems satisfactory. I chose instead to use a few, hoping that the reader for whom they are unfamiliar will know that the discussion can proceed without every word being fully understood, just as might occur between people who only partially know each other's languages.

[3]Data on the traffic over the Internat is available at ftp://nic.merit.edu/nsfnet/statistics/.

[4]Users must wear light plastic glasses to perceive the 3-D effect.

[5]The tablet was discovered in 1799, near the town of Rosetta in the Nile River delta. It was made out of basalt and inscribed with the same text in three different scripts: hieroglyphic, demotic, and Greek. It was produced during the reign of Ptolemy V, who ruled Egypt from 205-180 BC.

Table 1

A Small Sampling of Internet Resources

Activity	World Wide Web Location
See the "Home page" of the White House; listen to Socks the cat meow	www.whitehouse.gov
Get the latest medical information	cancer.med.upenn.edu:3000
Connect with Santa Claus	northpole.net, or www.neosoft.com/citylink
Plan a trip	www.travelweb.com
Look for a job	www.careermosaic.com
Find resources for education	www.ed.uiuc.edu
Attend an art exhibit	gertrude.art.uiuc.edu
Tour the solar system	www.c3.lanl.gov/~cjhamil/SolarSystem/homepage.html
Obtain government information; read Nelson Mandela's speech to Congress; examine corporate filings before the Securities and Exchange Commission	thomas.loc.gov
View paintings at the Louvre; tour Paris while there	sunsite.unc.edu/louvre
Visit the Electronic Frontier Foundation; become involved with the politics of the Internet	www.eff.org
Sample the latest music releases	sunsite.unc.edu/ianc/index.html
Read *Wired* magazine; meet with contributors and other readers	www.hotwired.com
Visit the Exploratorium in San Francisco	www.exploratorium.edu