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Why Computers are Transforming the Meaning of Education

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1. Introduction

The rise of networked computers through the Internet has inspired very different interpretations. Some see it as merely the next step in a long evolution. They note that global communications are not new; that Alexander the Great prepared the way with his pony express linking India with Europe in the fourth century B. C. In this view, the spread of the telegraph and the telephone in the nineteenth century and television in the twentieth century were preparatory stages for the multimedia evolution now underway.[1] Some see networked knowledge merely as an industry driven enterprise.[2] A third view sees the developments of the past decades as the beginnings of a revolution of monumental proportions,[3] a view for which this paper will explore further evidence.

By way of introduction, basic changes in capture and display methods are mentioned. The scope of new content that is becoming accessible is explored, as are the implications of access to these sources in a distributed knowledge framework with respect to collaboration and augmented intelligence. A fundamental development entailing the separation of content and presentation is outlined, as are its implications for the rise of meta-data, agents, delegation of work and the re-definition of learning.

2. Capture and Display

In the past images were captured mainly through two-dimensional photographs Some imagine that computers will merely reproduce these images on their screens, in which case it would simply be a case of translating analogue images to a digital form. Recent

developments in technology mean that much more is entailed. First, new cameras (e.g. the Vasari scanner, London) permit scanning at rates of c. 1.4 gigabytes per square meter resulting in much higher resolution than available in ordinary photographs. Second, new laser scanners (e.g. NRC, Ottawa) permit capture of images in three-dimensions such that one can see surface details such as brush strokes, cracks, even subtle surface layers of a painting. In the case of sculptures and museum objects one can produce images in the round which can be rotated on screen such that one can see all sides of the object. Stereoscopic images of these objects can also be created and viewed through lightweight stereo-glasses. Through new methods of stereo-lithography one can effectively reproduce three dimensional sculptures and objects on demand. Third, recent developments in x-ray technology permit one to view different layers of a painting, thus allowing one to trace different stages in the artistic process.

With respect to display of images recent breakthroughs in imaging technology permit one to zoom seamlessly from a distant to a detailed view of a painting. At the high level this requires a gigabyte (of RAM) and an SGI Infinite Reality Engine, as seen in Infobyte's reconstruction of the *Stanze* of Raphael.[4] Hewlett Packard has developed a mid-range version of this technology called Flash Pix and the developer of Apple's Quick Time V-R has produced a low-end version of the same principle called Real V-R. Traditional images were static. The new technologies render these images dynamic and allow the viewer to focus in or move back at will. Such dynamic images challenge the viewer to become more actively engaged in the experience of looking at pictures.

Considerable work is being done on stereoscopic displays in the context of high definition television (HDTV). Another trend is to produce auto-stereoscopic images, which do not require head mounted displays or even glasses and appear as three-dimensional images suspended in space. The net result of such developments is that they frequently allow us to see more through electronic images than we could see in the case of the original object. Thus new methods of display and capture are in fact redefining the very meaning of content with respect to the originals.

3. Distributed Content

In the past, access to materials was limited by those which happened to be available in one's local site. If one had the good fortune to be in a city with a major library such as London, Paris or Rome one had many more resources than if one lived in a village or on a farm. The rise of Inter-Library Loan expanded these horizons considerably on the basis of individual items one at a time. The rise of the Internet saw the emergence of major national networks such as BLAISE (Britain), PICA (Netherlands and Northern Germany) and international networks such as the Research Libraries Information Network (RLIN, which now has over 100 million titles). More recently basic texts linked with the reference section in libraries (dictionaries, encyclopaedias etc.) have been entered electronically and a series of initiatives have begun scanning in the full texts of sections of major libraries. Some of these have been led by major corporations. For instance, IBM is scanning in the Vatican Library, the Luther Library at Wittemberg, and the Edo

Museum in Tokyo. Xerox is scanning in the Gregorian Library. In the United States there is a national initiative for digital libraries, which to date involves at least ten projects.[15]

A number of individual museums and galleries have also scanned their complete collections of images, including the national galleries in London, Edinburgh, Ottawa and Washington and collections such as the Louvre (Paris), Uffizi (Florence) and Pushkin (St. Petersburg). Two approaches are emerging. In the United States a short term, pragmatic view dominates. In Washington, for instance, the National Gallery is scanning in its 105,000 images at 30 megabytes an image. In Europe, there is more concern that these images be scanned in once for the long term and at a level such that they can serve the demanding needs of conservators for collaborative, on-line restoration of paintings. Hence, the National Gallery of England is scanning in its images at c.100 megabytes per painting. They have also produced a lower level CD-ROM which has already sold 55,000 copies. The Uffizi, using the Vasari camera mentioned earlier, is scanning its images at 1.4 gigabytes per square meter.

These individual efforts are becoming linked with more global initiatives on a number of fronts. In North America, there are private efforts such as Project Gutenberg and larger initiatives combining private and public sectors such as the Text Entering Initiative (TEI) and the Coalition for Networked Information, which is planning to scan in 10 million books in full text. These projects fit into an American vision, which has both positive features and limitations. Very positive and laudable is their assumption that a basic level of these images would be universally accessible, to all citizens whether or not they are impaired in terms of sight, hearing or speech. Their great optimism about the feasibility of a universal databank of all human culture comes partly from seriously underestimating the scope of the challenge. A keynote speaker at the Sixth International World Wide Web Conference recently (April 1997) estimated that there were 100 million documents in the world. They were not aware that the RLIN database alone has that many titles or that a recent report of the European Commission based on the 75,000 major libraries of Europe (excluding archives), recorded 2.2 (European) billion books, (i.e. 22 times speaker's estimate for the whole world).

Meanwhile in Europe, the European Commission (EC) has introduced a Memorandum of Understanding (MOU) for Multimedia Access to European Cultural Heritage. This includes 282 museums and galleries, 25 governments and regional government organisations, 10 communications service/software companies, 2 Telecom/CATV operators, 22 IT-Telecom equipment companies, 22 members of the new media industry and 24 non-governmental organisations. The goal of the MOU is that by the year 2000, fifty percent of these major collections will be available in electronic form and lead to cultural industries in a new sense.

To this end, the European Commission, within the context of its Advanced Communication Technologies and Services (ACTS) is sponsoring a series of research and technology development projects in three areas: i) interoperability; ii) IPR protection and conditional access, and iii) advanced multimedia imaging, presentation, 3D and

virtual presence. The budget for these research projects alone is ECU 812 million. In addition, with a view to practical deployment and dissemination the Commission is sponsoring projects under five other initiatives, namely: i) Trans European Networks (TEN) for Telecommunications; ii) INFO 2000; iii) Raphael iv) structural funds under the European Regional Development Fund (ERDF) and v) the Euro-Mediterranean Partnership (MEDA). Some of these themes will be pursued with a greater emphasis on content within the fifth framework (1999-2004).

At the global level, the Bangemann Report inspired the G7 Information Society Exhibition (Brussels, February,1995). This prompted the seven leading economic countries of the world to initiate eleven pilot projects among which are education (pilot project 3), libraries (or Bibliotheca Universalis, pilot project 4) and museums (or Multi-media Access to World Cultural Heritage, pilot project 5). Efforts are underway to co-ordinate the MOU initiatives at the European level with those of the G7 at the global level. For instance, the MOSAIC project within the TEN framework is being proposed as a participant in G7 pilot project 5. There is also some discussion of creating a common front-end for all eleven of the G7 pilot projects.

Very few persons have understood fully the implications of these developments for problems of bandwidth on the Internet. Traditionally the typical connect time for a (voice) telephone call was c. 3.5. minutes. In 1996, the average connect time for a typical user of the Internet was estimated at approximately 35 minutes. There is now much discussion about the advent of the Network Computer (NC). Implicit in this arrangement is that the user needs to be on-line continually. For an average employee that would be eight hours per day. Let us assume that a typical user makes six calls a day, which would be about 21 minutes of connect time. Even an elementary knowledge of mathematics suffices to realize that if the estimated 40 million users all changed their demands from 21 minutes to 480 minutes there would be nearly a twenty-threefold increase in connect time. The use of stereoscopic HDTV, mentioned earlier, would require c. 55 megabits/second, and again dramatically increase the demands.

At present, a typical private user has a 28,800 baud connection. Operational research networks such as the Tuscany MAN, the Canadian Advanced Network for Research Industry and Education (CANARIE) and the U.S. Very high Bandwidth Network (VhBN) are operating at speeds between 45 megabits/second (OC3) and 155 megabits with a view to moving to 622 megabits/second. In April,1997, Pacific Bell introduced commercial services at 270 megabits/second. Meanwhile at an experimental level Nortel has already done a test demonstration at 6.2 megabits/second (OC 192). There is discussion of terabyte networks. The details of such numbers are not important for our purpose, which is to make a fundamental point. The network(-ed) computer revolution is something much more than a simple re-use of our old telephone and television lines. We need to re-connect the world with new networks of wires, and frequently in some combination with wireless modes. Establishing this network will be one of the major growth areas for the next generation. Maintaining this network will be a more lasting source of employment and business.

4. Distributed Views and Collaboration

One of the initial inspirations behind the Internet was not so much the simple on-line access to materials, but rather the possibility of being able to share distributed views at a distance through collaborative work. In 1952, some forty-five years ago, Douglas Englebart, the visionary pioneer who invented the mouse foresaw i) a version of e-mail which would be hyper-linked with ii) shared files, iii) a journal (library) and iv) external (offline) documents.[6] Engelbart's original vision centres on five words, Concurrently Developing, Integrating and Applying Knowledge, a process which he abbreviates to a single term, CODIAK.[7] This process, which comes from a direct sharing of information would be impossible in earlier learning environments such as a traditional (unwired) classroom, a library or a museum. Engelbart sees this process as the basis of an augmented intelligence.

In terms of profession and personality, Douglas Engelbart is worlds apart from Howard Rheingold, the author of *Virtual Reality*[8] and *Virtual Community*,[9] a founder of the WELL, of *Hot Wired* and more recently, *Electric Minds.* In terms of basic approach, however, there are some striking similarities. Rheingold, for instance, tells a story of an event that convinced his wife of the value of his seemingly excessive "surfing." One evening, their daughter was inflicted by a tic. His wife rushed out to find a doctor. Howard went on line and asked for help. Before the doctor had arrived someone on the web had provided necessary knowledge about what to do under the circumstances. At a very practical level this is an excellent illustration of augmented intelligence as described by Engelbart.

It is instructive to note that these views of augmented intelligence are very distinct from notions of collective intelligence, which have been popularised by other recent authors (e.g. Levy[10]). Augmented intelligence is about persons sharing their particular knowledge to arrive at new insights. It is about the development and deepening of individual personalities. They may work together. They may form teams but they remain individuals. Indeed their individuality grows in the process. Collective intelligence, by contrast, implies that the intelligence lies abstractly in a collective group rather than in a concrete individual. In this view the individual as such is implicitly flawed until they are networked in a group which is somehow the locus of this elusive new intelligence. In this view the group is more important than the individual and in some mysterious way the collaborative efforts of the group are held to be more valid than those of an individual on their own. Those who study history may see more than passing resemblances between these two approaches to intelligence and the debates of a century earlier between Kierkegaard (the individual is the locus of truth and development) and Marx (the group or masses are the locus of truth and development). Students of history may also remember the pitfalls of setting groups above individuals encountered in the 1930's.

Augmented intelligence, in Rheingold's view --and implicitly Engelbart's also--, entails a web, which is much more like a telephone than a television: i.e. it is an active experience for sharing and collaboration rather than simply a passive object which provides one with information pre-sorted by someone else. This is rather strikingly different from an

emerging market driven view of the web, which typically speaks of cultural industries and collective intelligence. One is tempted to dismiss these differences as merely academic distinctions. It is true the extreme version of the exclusively market driven view is more prevalent in universities than in the frontiers of high industry. Nonetheless, the implications of this view are anything but academic. On the industry side its proponents almost invariably speak of (active) information service providers and (passive) consumers. Rhetorical reference may be made to interactivity, but only in the sense of passive users following choices made by active producers and providers. In academia, the most extreme proponents of this view pretend that business school is highest in the echelons of (academic) subjects and that only projects which bring in money are legitimate, as if scholarship were a straightforward money making proposition. More subtle proponents of this view favour collaboration almost for its own sake. In education this is especially true of the constructivist school, who hold that learning is essentially about creating world views which they believe is fostered by collaborative work. They see the work of groups as more important than the solid thought, reflection and writing of individuals. Hence those who do work in groups are favoured over those who work in "isolation."

Underlying the differences between augmented and collective intelligence are, in fact, two competing views of the web and its functions. At first sight, it might seem that this conflict is a simple one between realists who recognise the importance of economic facts, and idealists who have forgotten that they are living in the real world. It is important to realize that the real battle lies elsewhere. It is not a question of economics vs. an uneconomical approach but rather a battle between an exclusively market driven view and a gift economy. Extreme versions of the market driven view depart from a two-fold business case scenario which a) believes that everything can be reduced to a business proposition in the form of a transaction or b) that one can at least control everything through licenses which are bought. Unfortunately these assumptions do not apply to culture.

In geometry, one of the ways to proof is to assume that a given claim is true and then follow its consequences until the absurdity of the argument reveals itself. Applied to the topic at hand, this approach might run as follows. Business case one assumes that everything can be bought and hence everything has a price. On the surface this is right. One can point, for instance to a very famous manuscript such as the *Evangel* of Henry the Lion, which was auctioned in London a few years ago for over eight million pounds. This manuscript is now shared by the Herzog August Bibliothek in Wolfenbüttel and the Bayerische Staatsbibliothek in Munich. The library of Duke August of Lower Saxony was once the greatest in the world and has had Leibniz and Lessing among its librarians. It has c.12,000 manuscripts and c. 810,000 books, many of them unique copies. The *Evangel* is a special case. At our hypothetical bargaining table we could agree that the average cost of a precious manuscript is much less than the *Evangel*, say one million dollars. The cost of the manuscripts at the Duke August Library would thus be 12 (U.S.) billion dollars. Books are much less expensive. Some may be ephemera. Some books such as a Gutenberg *Bible* can easily be worth a million for a single volume. At our bargaining table we might decide on a bargain price of a 10,000 dollar average per book.

The 810,000 volumes would thus be available for a mere 8.2 (U.S.) billion. The manuscripts and books together [11]would cost 20.2 (U.S.) billion. In addition, there are also some 20,000 maps, 26,000 portraits, 950 precious books hand painted by some of the most famous painters of the twentieth century, archival materials, a music collection, a reference collection of 210,000 books. These are all housed in three buildings one of which is a unique historical monument, another of which was the former home of one of Germany's greatest poets. In the interests of brevity these might be lumped together for an additional 4.8 (U.S.) billion, which means that this single famous library would be available for a round sum of 25 (U.S.) billion. This amount is close to the price paid for some of the most dramatic mergers of the past decade, which are also the greatest mergers in history.

In the corporate world, mergers typically occur between two giants in a field where the number of others is seldom more than a half dozen. In the world of culture, matters are very different as becomes clear if we pursue our argument. The Vatican Library, for instance, has c.150,000 manuscripts. These are no less precious than those of Wolfenbüttel. By the market standards established above, the Vatican's manuscript collection could theoretically be bought for 150 billion dollars. Its million books would readily be worth another 20 billion and the secret archives would easily be worth another 30. The map collections, decrees, coins and other artefacts in the library would make another 100. That makes 300 for the library alone, which is part of a much larger complex. Saint Peter's with its inestimable treasures would readily be worth another 300. The Sistine Chapel could fetch 50 as could the Stanze of Raphael and the Borgia Apartments. The painting gallery would easily be worth another 100, as would the Ancient sculptures. Lesser collections such as the Egyptian, the Etruscan, the Chinese might go at 50 each. Even omitting the great hall of maps, the halls of tapestries, and other church objects, the Pope's apartments, the other administrative rooms of the College of Cardinals, the gardens, or the great courtyard and balustrade of Bernini, the radio station, the quarters of the Swiss guards, we have arrived at a figure of 1.15 (U.S.) trillion dollars. Hence a serious offer for the whole complex would need to be at least 2 trillion (U.S.) dollars. As a single expense this exceeds the budget of any corporation and even any government. In the context of Rome, however, the Vatican does not comprise even 1000th of all the treasures of the eternal city. At a conservative estimate therefore, serious bidding for the culture of Rome alone could begin at a sum above 2,000 (U.S.) trillion dollars.

The culture of Rome does not amount to a 1,000th of the whole of Italy even if one limits one's horizons to high culture. So a reasonable bid for Italian culture might begin at a sum above 2,000,000 trillion U.S. dollars. Small wonder then that an individual who paid over 30 million for 72 of Leonardo's 6,500 pages was not taken seriously when he offered 2 billion for the images of French culture, which does not deem itself to be inferior to Italy. The point of this excursus is a simple one. Even if everything could be bought, we would rapidly have to conclude that no individual, no corporation, no consortium or even the richest government could even attempt to consider purchasing the cultural heritage of even a single, major European country, let alone the world as a whole. This is a domain where notions of possession, take-over bids and stock options will not

work. The notion of buying content may apply to evanescent films but it cannot apply to culture.

Having conceded that we cannot own everything,[12] business case two assumes that licensing for control is the answer. Licenses are typically some fraction of the full cost for a limited term of say five years. In the business world, a license for one percent of the original would be very conservative. Keeping with our hypothetical assessment above, a license for the whole of Italian culture would thus amount to a mere 20,000 trillion U.S. dollars, payable once every five years, which is still considerably beyond the budgets of even the biggest players. In short, the extreme view of business whereby everything can be either bought or licensed cannot apply to culture. It is a myth.

That business cannot own or control culture, does not exclude their working together. If business invests x dollars in scanning the images of a museum, they can fairly expect that when the museum makes money from the resulting electronic images, then the business will be re-imbursed. Business will have indirect incentives for doing so also. Cultural content has great appeal. Almost everyone has some interest in Leonardo's *Mona Lisa*, or Michelangelo's David, or at least would have us believe that they are. With a greater amount of culture more persons will need computers and more persons will use Internet lines (phone, cable, wireless etc) in order to connect with great repositories of culture. Culture provides one of the whys for the products of computer firms and telcos.

This scenario becomes even more attractive if viewing low level versions of the images is available at no costs (other than the transmission) and payment is associated with detailed versions, printouts as postcards, posters, slides, sculptures on demand, special interpretative projects (e.g. films) as well as obvious adaptations for advertising. Once the content is available and there are tools for its publication and interpretation, then there are large new markets for machines and pipelines, and new services in terms of training and maintenance. Some clues for reaching this goal may lie in what appeared at first to be an opposing view.

If the view espoused by Engelbart and Rheingold could seem overly idealistic and ultimately unrealistic, it should be noted that one of its most articulate champions is also one of the paragons of capitalistic, entrepreneurial, free-market business, namely, Apple Computers. Some of the leading spirits at Apple note that Apache, one of the best examples of server software available today is a result of volunteer co-operation rather than from a commercial company and is available free of charge. They also point out that when Apple was developing the programming language, Smalltalk, they came to an impasse due to lack of funds. An estimated two million dollars would have been needed. They decided to make the code freely available and within six weeks, volunteers had accomplished without money that which had seemed economically impossible.

Such experiences led Apple consciously to contrast a narrow, strictly market driven, money economy view with their notion of an educational object economy, which as they are well aware, is based on the principles of a gift economy. Their idea is simple: create an Apple Application Tool Kit, which would effectively serve as the first letters of a

software alphabet. A user wishing to adapt letters *a*, *b* and *c* of that alphabet with their own letters *d* and *e* in order to create a new product, would be at liberty to use them at no cost. The proviso would be that they submit the resulting product in the free repository. On the other hand, persons wishing to charge for their results would be charged proportionately for the pieces they acquired from the repository.

The Apple initiative can be seen as part of a larger global trend. Visionaries at Apple such as Steve Cisler, are actively studying the phenomenon of communities, not just the virtual communities of which Rheingold speaks, but the underlying principles which inspire persons to work together. This topic also being studied by the (Marshall McLuhan) Global Village Conference (Franz Nahrada, Vienna), which is becoming a focal point for the emerging field of intentional communities, namely, groups of persons who have deliberately chosen to live in a place rather than simply moving into a neighbourhood by chance.

At the same time the Apple approach relates to the philosophy of freeware on the Net, as in the GNU[13] project of the Free Software Foundation. It consciously builds on principles introduced by some of the developers of Java applets[14] and relates closely to a growing trend toward open standards. Ironically, Apple which initially began in opposition to the legacy systems approach of the old IBM, went on to develop its own proprietary software. IBM then played a key role in founding the Object Management Group (OMG), which developed the Common Object Request Broker Language (CORBA). The Open Group (which sponsors the Open Software Foundation, and the X/Open Group), the Open GIS Consortium, the Open Microprocessor Initiative, the Office of Open Information Interchange (OII), the World Wide Web (W3) Consortium and G7 pilot project 2, Global Interoperability, have the same stated aims. A next challenge lies in all these bodies agreeing on a single corpus of core standards, which will make the universality of the Web a reality.

When we use a telephone, we think of it as hardware. Actually it is both hardware and software. Yet we never think of buying another software package every time we want a new feature. We pay a standard rate and then more for features. Needed is a consortium between the telcos, computer manufacturers, television companies and other players to produce a set of tools which work seamlessly. In the case of digital television[15] there is talk of a 10-20 year transition period in moving form analogue to digital methods. If we begin now with practical tests involving actual users in classrooms and research sites as well as in trial homes, then a universally acceptable and useful interface can evolve in pace with the transition.

As for the new content that is needed, it is instructive, in this context, to recall that the great breakthroughs in content production during the Renaissance would almost certainly have been impossible if tens of thousands of monks working in mediaeval monasteries had not spent centuries preparing source materials in intentional communities on a volunteer basis. In the Middle Ages, these extraordinary efforts were possible because a great percentage of the population was effectively unemployed. A number of futurists are predicting a similar trend towards unemployment in the near future.[16]

One of the most dramatic of these scenarios was explored in November of 1995 in a meeting with 500 world leaders organised by Michael Gorbachev (San Francisco). Here the claim was made that, with advances in technology, within a generation 20% of the population will be employed doing regular jobs and 80% will be unemployed. Their proposed solution was that these new masses of unemployed be distracted with a variant of the Roman tradition of bread and circuses with sex added, "tittytainment".[17] While, it is tempting to dismiss this merely as excessive pessimism, wrapped in bad taste, it is sobering to note that the non-fiction account of the meeting has become a best seller in Austria and Germany and very much *a cause célèbre*. A much more attractive scenario would be a revival of the learning dimensions of the monastic tradition without the dogmatic excesses. Thus one could use an enormous new voluntary work force to arrive at new organization, interpretations and insights concerning culture which will be of benefit to all.

Such a revival of monasticism could also address another fundamental problem. Thus far much of computer software has been designed for business activities which did not exist prior to computers, work flow diagrams, new levels of financial planning, retirement programs and the like. They are sold on the pretext of saving time. Unfortunately they computers save time with respect to distractions they have in turn created. Where are the programs that help us gain serious access to world knowledge, help us to understand the reasons for alternative explanations to truth, philosophical insight or religious inspiration? For economic reasons, computers have addressed business needs more than human ones. A revival along monastic lines could redress the balance.

5. Separation of Content and Presentation

In the world of books there has been a traditional separation between the process of writing the content of a book (author) and the presentation tasks in preparing it for publication (layout person, typographer, editor, publisher, printer). Even so the product of these efforts was traditionally a book in which these processes of content (creation) and presentation were intertwined. In the 1960's and 1970's, those at the frontiers of electronic editing recognized that in the new medium these two processes could be treated as separate functions. To this end a Standardised General Markup Language (SGML) was developed.[18] This became a standard for scholarly groups such as the Oxford Text Initiative and the Text Encoding Initiative (TEI) and was adopted by major document management firms such as Xerox and Intergraph.

Critics complained that SGML was unnecessarily complex. To an extent they were right. SGML was designed for dealing with the complexities of a) high-level scholarly publishing (footnotes, diacritics, accents, special characters in Old English, multiple notations) and b) the sheer volume of a major corporation such as Boeing, which produces manuals weighing more tons than the 747s they describe could lift. These tasks require(d) subtleties well beyond an average user's needs. Hypertext Markup Language (HTML) offered an alternative much closer to these everyday needs and enjoyed a meteoric rise. HTML was also an informal stopgap measure rather than a methodical

solution. It conflated the distinction between content and presentation which SGML had laboriously distinguished.[19] The World Wide Web (W3) Consortium is committed to provide more felicitous solutions. Those with complex needs will continue to use SGML. For those with everyday needs, the team at W3 is creating a simplified version of SGML called XML (Extensible Markup Language). To meet the different presentation needs the team is developing cascading style sheets. In the near future it will be possible to have a single content document, which can then be presented and published in the form of many different "views", including versions accessible to those impaired visually, vocally or aurally.

In the short term, the W3 Consortium is working with industry partners to produce tools for four specific markets: web publishing, intranets, electronic commerce and education which includes training. The vision of Tim Berners-Lee is that fulfilling these short-term needs will help realize the long-term goals of personal empowerment, social efficiency, understanding and harmony and exploiting computing power in everyday life to solve problems and augment the capacities of persons.

6. Meta-Data

These tools entail much more than easier and faster ways of producing web pages. They entail new methods for getting at the already enormous mass of information existing on the web which is increasing daily. The earliest search engines either surveyed URLs or searched the full contents of the web-site. The first of these strategies was typically too imprecise or summary. The second strategy is increasingly too cumbersome. Browsers provided an alternative approach by creating personal classifications of terms in hierarchical lists as an intermediate step to searching materials. Until recently there was a clear distinction between search engines and browsers. A search engine such as Altavista allowed a user to choose a term, which would produce a number of hits. A browser such as Yahoo allowed a reader to browse through predetermined lists of subjects hierarchically arranged, choose a term and then call up the associated hits. More recently new tools such as Infoseek,[20] and Webcompass [21] are combining the features of search engines and browsers. A reader types in a term. The search engine finds a series of hits and also a series of related topics, which can be browsed in order to arrive at further hits. The Stanford Digital Libraries Project[22] is developing this approach with new tools such as SenseMaker.[23] These are but isolated examples of a larger picture.[24]

1	2	3	4	5	6	7	8
URL	URN	URI	Mime Types	Site Mapping	Content Mapping	Library Metadata	Content Negotiation
						ISBD-ER	PICS

Figure 1. Eight ways in which information about information is helping the quest for understanding on-line materials

New tools are focussing on providing information about information, generally termed meta-data, tagging original documents to produce the equivalents of brief summaries, such that search tools can scan these without having to read the full contents at every turn. These include at least eight different kinds of initiatives (fig. 1), which range from short term stop-gap measures to long term solutions. The most basic of these entails adding greater precision to the initial header to the information. One initiative, led by the W3 Consortium, entails supplementing the convention of a Uniform Resource Locator (URL) with a Uniform Resource Name (URN) and a Uniform Resource Indicator (URI). Meanwhile, the library world is creating an International Standard Bibliographic Description for Electronic Resources (ISBD-ER).

A second step, in which Xerox is playing a significant role, entails a more systematic definition of media types, or MIME types. Suppose, for instance, that a user is searching for databases on ecology. Assuming that databases are identified as a media type, then a search can go directly to sites with databases and can skip all other sites where databases are lacking.

A third initiative, involves some measure of quantification using visual tools. To this end, James Pitgow, a student at Georgia Tech, --now at Xerox PARC--, developed a method of mapping the links between a home-page and the hierarchies of topics connected therewith, inclusive of hyperlinks among sections such that one can discern which pages are crucial in any given site. This permits one to see at a glance whether the home page is merely a façade to a few random pages or an entry point to a large body of systematically organised material. This concept of site-mapping will soon appear as a new product of Microsoft.

Related to this is a fourth action, which might be called content-mapping. In the case of databases, this would gather data about the parameters or constraints of the information contained therein. This might, for instance, explain the temporal limits of the materials, that it is only between 1850 and the present; or the geographical boundaries, that it covers only North American materials. Such constraints will also become part of search strategies. For example, when one specifically wants news about Amsterdam, then it would make sense for a search engine to focus on what resources Amsterdam has to offer rather than searching all the web sites on the other four continents at the outset.[25]

A fifth set of steps entails tools to provide automatic abstracts of content. For example, as part of its Application Tool Kit, Apple is working on a product called Vespa, which will serve as an editorial aid for summarising documents. Special algorithms will allow one to have a one page summary, a one paragraph abstract or even a single sentence outline of an article. They are also developing a product called *Hot Sauce*, already on the web,[26] which allows hyperbolic hypertextual linking and editing. In the longer term such initiatives relate to a bigger picture being developed at Xerox, which distinguishes between four elements: the infosphere, workspace, sense making tools and the document. Xerox PARC is working on various new methods of information visualisation.[27] Some immediate implementations are being spun off through a new company termed Inxight, while they continue to work towards a long-term solution. They have, for instance,

developed search strategies using a scatter-gather method, which go beyond the simple keyword searches prevalent today. Another group in Grenoble is focussing on digital library solutions.

Loosely speaking all five of the initiatives listed above can relate to meta-data in general, i.e. producing information about information. A sixth set of initiatives, which we can term library meta-data is building on the cumulative experience of the library world and scholarship. In 1995, the Online Computer Library Company (OCLC, Dublin, Ohio), in conjunction with the National Center for Supercomputing Application (NCSA, Urbana-Champaign), organised a first meta-data conference. This resulted in the so-called Dublin Core[28], a set of twenty essential terms (names of fields in databases), whereby libraries could share data about their data, effectively creating the potential for interoperable pointers to works and their contents.

A second meeting in Warwick, England[29], (1996), produced "the Warwick Framework: a container architecture for aggregating sets of meta-data."[30] This discussed more closely the problem of interoperability between different catalogues, which may use alternate words for the same term. For instance, one library may have a field for "Author", whereas a second library has a field for "Name," while a third has a field for "Artist." A person searching from a remote site for literature on Michelangelo has no interest in checking what the variant heading happens to be in different libraries. They simply want the system to search seamlessly in the appropriate fields to acquire the relevant literature. The Warwick framework raised awareness of this problem and prepared the way for a solution.

A third meeting in Canberra (March 1997), focussed on three items:1) a syntax for element refinement; 2) a scheme to record how this term is encoded, e.g. the Library of Congress Subject Headings (LCSH or MESH which could potentially permit links to different classification schemes) and 3) a tag to qualify in what language it is. Participants of these meetings span a large range of individuals from the library world, major industry and governmental institutions. Taken together these initiatives for meta-data promise a new set of intermediary records which will be the equivalent of abstracts on the Web so that we do not have to crawl literally through the full texts of documents which may not interest us.

A seventh set of initiatives focusses more on rules for exchange of content. The Warwick framework explored the concept of discovery packets, as well as permission to use packets and procedures for an issuing agency. The W3 Consortium is also working on meta-data tags for Intellectual Property Rights (IPR), terms and conditions, access control, and information about people, objects (and presumably places).

Finally an eighth set of innovations is focussing on the quality rather than the quantity of the information. For instance, the introduction of digital watermarks both visible and invisible will allow libraries and museums to authenticate their images and track their usage. IBM has introduced this into the Vatican Library project. The Platform for Internet Content Selection (PICS), another W3 Consortium project, initially developed to provide

a rating system for parental selection (analogous to that which the V-Chip purports to do), is being broadened to cover endorsement in general. A parallel project, in the form of Java applets will produce Digital Signatures (DSig), which will permit signed metadata and thus provide the foundations for a certificated web. In the world of traditional print we are well acquainted with rating systems ranging from the stars in a Michelin guide, a movie review or a hotel front. Tools such as the above will help us to integrate these functions into tools for the Internet.

7. Implementations and Developments

Ideas are fascinating. They need to be implemented in order to change the world. Serious implementation requires a critical mass of followers such that the ideas can truly become universal standards. This is happening in the case of meta-data.[31] Support is coming from four main areas: libraries, government agencies, industry and the military. (fig. 2). The OCLC/NCSA Dublin-Warwick Framework is co-operating with the largest U.S. database in the library field, namely, the Research Library Information Network (RLIN) of the Research Library Group as well as the Library of Congress, which has been developing the Machine Readable Bibliograhic Information (MARBI), Machine Readable Card (MARC) formats and the Z.39.50 protocol. In turn, the Z.39.50 protocol has been accepted as the Gateway to European National Libraries (GABRIEL) and has the support

A. International Standards Organization (ISO)
B. International
- AEGIS for G7[32]
- Document Management Alliance[33]
- World Wide Web (W3) Consortium

C. National
- ARPA Knowledge Sharing Effort (ARPA)[34]
  - Knowledge Query Manipulation Language (KQML)[35]
  - Knowledge Interchange Format (KIF)[36]
- Biological Metadata[37]
- Metadata Council[38]
- Metadata Coalition[39]
- World Wide Web (www)[40]
- Miscellaneous (OII)
- American National Standards Institute (ANSI)
  - X3L8[41]
  - X12

D.
- International Electrical Engineers (IEEE)[42]
- Scientific Metadata

E. Major Companies
  - Xerox Metaobject Protocols[43]

Figure 2. Some of the key players in the field of meta-data.

of the International Federation of Library Associations (IFLA), which has become a reference point for many of the metadata resources. .[44] At the international level also, a representative of G7 pilot project 4, Bibliotheca Universalis, has been following the meta-data developments

As for the military, in the United States, for instance, the Defense Advanced Research Projects Agency (DARPA), is extremely active in this domain. It has introduced concepts such as Knowledge Interchange Format (KIF) and Knowledge Query Markup Language (KQML) and has initiated an ARPA Research Program on National Scale Information Enterprises. In terms of industry, the efforts co-ordinated by the W3 Consortium have already been mentioned. The Open Group is also actively studying meta-data. Perhaps the most articulate public statements have come from Apple, who have published a call for a Metadata Framework.[45] Other companies such as IBM, Xerox and NEC are using metadata in their quest to establish one-stop solutions for culture and business.

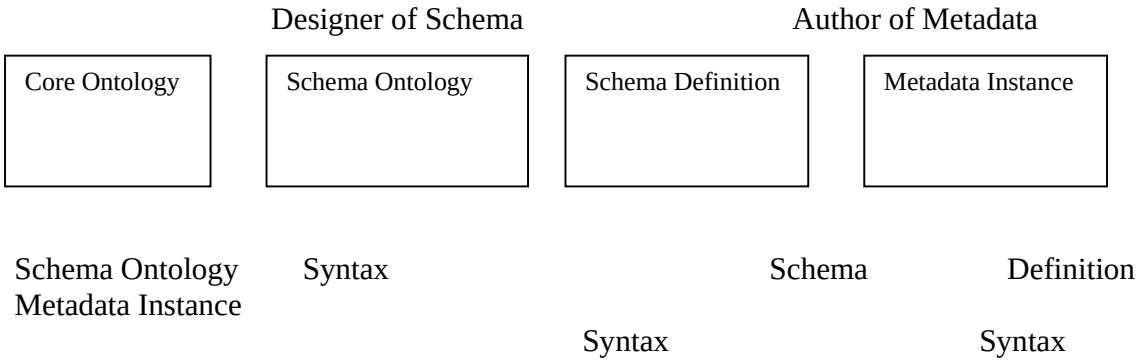

Fig. 3. Structure of the Multi-Schema Metadata Format by Digital Vision Laboratories.

Digital Vision Laboratories[46] is also doing very interesting work. They have created a Multi-Schema Metadata Format (MMF) and a Metadata Mediation Protocol (MMP) as the basis for an electronic commerce mediator. Their initial goal was fairly straightforward: to include characteristics of merchandise (the dress should be a given colour, size, cost), as constraints in a catalogue based retrieval system. This goal was complicated by the fact that such catalogues may use different terms to describe the same thing. The customer is searching for a dress, which may be listed under *women's garments* in one catalogue and *ladies apparel* in another. They solved this problem building on the architecture outlined in the Warwick Framework to arrive at the schema above (fig. 3).

The above is another example of how the OCLC/NCSA approach is gaining wide implementation. It confirms how business applications are profiting from experience in organization in the library world. Their pragmatic solution to a problem in everyday shopping is of further interest, because it can potentially be useful in solving two important problems in the library field. One is multiple classifications for a single term, which serves as an excellent potential tool for entering into the mind sets of different

cultures. A second is the problem of related terms. A reader is searching for a book on one subject. They notice that the book also deals with other related subjects. By using these related terms the reader typically discovers valuable new materials. This process which is presently manual could be automated using the new Metadata format outlined above.

All this points to a model that goes far beyond the initial search engines. Such a model will have at least seven layers, namely, i) the user, who has access ii) to a variety of views and a iii) tools for examining iv) an object of study to which they can then apply v) basic library metadata before entering upon vi) content negotiation metadata, in order to gain access vi) to relevant contents (fig. 4).

Layer				
i.	User			
ii.	Views			
iii.	Tools (Editing, Searching, Browsing)			
iv.	Object of Study			
v.	Basic Library Metadata			
	Dublin Core Fields	Warwick Framework	Schema of Subject Headings or Classifications	Language
vi.	Content Negotiation and PICS Metadata			
vii.	Contents			

Fig. 4 A seven layered approach to meta-data.

To recognise why this is only the beginning of what is needed, a brief excursus on the structure of libraries is necessary. In the world of the great libraries the problems of meta-data are hardly new. For centuries, the great libraries had too much data to permit any one individual ever searching through every document, let alone read each one carefully. So reference rooms with at least five levels of meta-data were designed. Reference rooms contain 1) subject catalogues and classification systems, which provide the reader with a standardised set of terms, with clear indications where those terms fit in a hierarchy of ideas, i.e. references to both more universal concepts or Broader Terms (BT) and more specific or Narrower Terms (NT). Reference rooms also contain 2) dictionaries to provide readers with definitions of terms with which they are unfamiliar. They contain 3) encyclopaedias, which provide a slightly deeper insight into such unfamiliar terms and, of course, they contain 4) titles. These include a) card catalogues, b) (national) book catalogues and c) bibliographies. Book catalogues range from historical works, such as Heinsius to *Books in Print*, which are lists of titles pointing to more detailed literature (both primary and secondary) about those terms. Bibliographies are effectively a further sub-layer of meta-data insomuch as they establish links between primary works (level 6) and the secondary literature about those works (layers 7-10). Reference sections also contain 5) literature about that literature in the form of abstracts (which summarise quantity), reviews (which summarise quality) and citation indexes (which are bibliometric pointers to and, some would claim, indices of quality). The rest of the library

contains 6)[47] the full contents of these books (primary literature) and 7-10) various levels of studies about these books, i.e. secondary literature (see fig. 3).

Library automation typically began by focussing on level 4) card catalogues and in some cases included samples of 6) full contents. In the past decade, work has begun on most of the other levels, namely, 1) classifications systems (e.g. Electronic Dewey); 2) dictionaries (e.g. the Oxford English and Websters); 3) encyclopaedias (e.g. the Britannica and even classics such as Thieme-Becker) and 5) citation indexes in the Humanities and Social Sciences etc. The latest advances in meta-data outlined above (fig.4) are effectively only subsets of level 4, with some references back to the subjects and classes of level 1.

A full treatment of meta-data will require a systematic correlation between all five levels of the reference sections of a library with the remaining five levels. A reader could then choose a term, see where it fit into different classifications in order to obtain a larger vocabulary, check the meanings thereof in dictionaries and/or encyclopaedias, search for titles on this topic, and then check abstracts, reviews and/or citation indexes before reading the actual books. Technologically, such a system is possible today. It will effectively bring the immense power of reference rooms in great libraries available to everyone on their desktop. Digital libraries are a wonderful idea but we need to begin with digital reference rooms. Otherwise it is like building wonderful houses without doors and windows. We need systematic entry and exit points (fig. 5).

Layer		
i	User A	User B
ii	User A views	User B views
iii	User collaboration tools	
iv	Object of Study	
v	Library Meta-data	Digital Reference Room
	Content Pointers	
	1. Terms	Subject Headings, Classifications
	2. Terms of Definitions	Dictionaries
	3. Terms of Explanations	Encyclopaedias
	4. Terms of Titles	Card Catalogues, National Book Catalogues, Bibliographies
	5. Terms of Partial Contents	Abstracts, Reviews, Citation Indexes
vi	Content Negotiation and PICS Meta-data	
vii.	Contents	Digital Library of Primary Literature: Facts
	6. Full Text, Image	Facsimiles of Original
viii	Contents	Digital Library of Secondary Literature: Interpretations
	7. Internal Analyses	Descriptions and Studies of Contents in 6
	8. External Analyses	Studies of Objects, Subjects Related to 6
	9. Restorations	Descriptions and Methods How Objects in 6 were Restored
	10. Reconstructions	Models, And Other Substitutes of 6

Fig. 5. Preliminary diagram for a bigger picture with eight layers linking user to content, integrating ten levels of knowledge as developed in the SUMS framework.

To render the resulting meta-data lists more workable, all the materials in the top five levels of knowledge would be broken down in terms of questions. Hence a person interested in biographical materials would query only those subsets pertaining to who at each of the levels, whereas a person looking for chronological information would query only subsets pertaining to when. It should be noted, moreover, that this level of queries would only be used in very complex cases.

Traditionally one only went to a major library if the material being sought was not available locally. So too will it be with online queries. Many questions are very specific and can best be answered by going to specialised databases, which have grown enormously even during the past year (1996). For example, someone wishing to find out about films would go to the Cardiff database on that subject. These will account for a majority of simple questions. More complex questions will require more complex tools accordingly. To this end each of the initiatives outlined above should be seen as complementary. In some cases, a URL, URN, URI and/or an ISBD (ER) will be sufficient. MIME types will be essential for those wishing specific kinds of media, e.g. video or databases. Site Mapping might be a default strategy for all web- sites with more than 100 pages. Similarly abstracts could be a default strategy for someone needing to master a field with hundreds of articles and books, as could the use of some kind of authentication and rating tools. Only some will need to enter into all the complexities of a major meta-data system and even this would be rendered more accessible by indications

of different levels of education for which the material was written. This would permit beginners to start with introductory literature and experts to enter at the appropriate level.

Further advances will require new levels of cataloguing for existing collections. For although distinctions between primary and secondary literature are well established in theory, in practice most libraries provide no systematic links between a given primary source and the four levels of secondary literature outlined in our schema. The research of Professor Beghtol (Toronto) suggests that narrative discourse analyses can help in the refinement of classification theory. This would entail elements such as non-random characters (including narrators), events (human or non-human), settings (places, times), completion (resolution, end) and perspective (voice, point of view) in order to identify whether texts were descriptive, narrative, argumentative, literary, poetic, scientific, didactic or conversational. Such new levels of order would allow the access methods for meta-data to be refined accordingly.

In light of the above it is easy to discern why the initial search engines and browsers had such primitive results. They ignored most of the knowledge framework which libraries have laboriously developed in the course of the past three thousand years. Browsers such as Yahoo relied almost solely on personal lists of terms (a non-standardised treatment of level 1). In this context it also becomes clear why digital libraries in the fullest sense require much more than a simple scanning in of the pages. The scanned works have to be translated and new links need to be made. It may take generations to achieve this new integration of knowledge that looms as a promised land, but the sooner we begin, the sooner we shall progress towards the goal.

7. Agents and Delegation

The notion of metadata has enormous implications. It is intimately related to a whole series of new buzzwords, chief of which is agents. Some futurists such as Nicholas Negroponte and Brenda Laurel assume that agents will effectively become electronic butlers who will do our work for us. Lurking in this over optimistic techno-idealism are dangerous assumptions, or at least temptations, notably that technology can replace essential human activities

If we return for a moment to the schema in figure five, it will be seen that a (digital) library effectively has three quite separate parts namely, a reference room, a section for facts (primary literature) and a section for interpretation (secondary literature). Traditionally a great deal of time has been wasted simply sifting through the analogue versions of reference rooms in order to seek out where one might get a copy of the actual facts.[48] Agents would be ideally suited to do most of that work of finding things (which will typically range from 25-95% of a scholar's time). The user, reader, scholar decides what they want. They delegate to the machine the challenge of using digital reference rooms until they have sifted out what is being sought. Hence in terms of figure five, computers are particularly suited for helping in section one of the library.

Potentially, of course, machines can do much more than find sources. As was noted earlier they can readily handle conditions, parameters, constraints. These features are already being explored for their applicability to rating systems and they could be extended to help in the process of verifying facts, the second realm of the digital library. An obvious way is through digital signatures. A more subtle way would be in comparing texts. If it is known that a student accessed 742 texts, then machines could do a word search to see whether plagiarism was entailed. Such techniques could equally be applied to scholars, and in the analysis of texts when one is trying to assess more closely the sources of a Montaigne, an Erasmus or a Dante.

These constraint tools can also help in the realm that was central in traditional scholarship, namely interpretation. At present we have spreadsheets which translate lists into charts such that we can see new patterns in the evidence. This ability is already generating new fields such as scientific visualisation and data mining. It takes little effort to see how this could be pushed much further. New image software such as IBM's Query by Image Content (QBIC), as well as products by Illustra (now Informix) and Excalibur, are beginning to permit machine detection of colours, patterns and shapes. Given the potentials of constraint language one could therefore delegate the machine to find all paintings with a *Virgin and Child*, all paintings with a given face, or even all paintings in a given "style", assuming of course one could define it with sufficient precision. In terms of figure five, computers can thus help in the third section of libraries as well.

Object-oriented programming is leading to a whole new approach to objects.[49] In the field of Computer Aided Design (CAD), for instance, a consortium led by Autodesk is developing the principle of industry foundation classes. Hereby, a door is treated as an object (in the computer sense), such that a door for a cottage automatically adjusts to the features of a cottage door, whereas a door in a skyscraper will automatically take on the characteristics of a door in such a building. In the parlance of salesmen, the door "knows" the shape that it has to take on in different environments, i.e. it is a "smart door." In the past, one had to draw each door anew. Now one simply invokes the door (as a computer object) and it automatically becomes what it has to become (reminiscences of Aristotle's notion of entelechy).The danger with this approach is that it feeds into the McWorld syndrome to which Barber[50] drew attention, whereby every Hilton around the world looks indistinguishable, whereby a suburb of Paris is effectively indistinguishable from a suburb in Germany or the United States.

Traditionally each country and even each city had its own variations on stock objects. For a time almost every column in a mediaeval church was uniquely carved. In secular architecture, a façade in Braunschweig was slightly different from those in Wolfenbüttel nine miles away, different again from each and every city within a hundred mile radius, including Hornburg, Hildesheim, Goslar, and Quedlinburg. Each of these variants can be seen as local constraints. If each local town enters their own values within a standardised framework, then CAD objects in Hanover can automatically enter the local features to doors and other elements. In short the next stage to universal foundation classes is to add cultural dimensions which adjust geographically and temporally (i.e. historically), such that one could see, for instance, what the local Renaissance style would have been.[51]

A parallel revolution is occurring in the field of maps.[52] Tile caching methods will soon allow users to zoom seamlessly from space and link with any spot on earth. This geographical information can be linked with global positioning systems, with Computer Aided Design (CAD) programs, with Area Management/Facilities Management, with historical view to produce whole new landscapes of knowledge.[53] Some see spatial techniques as essential metaphors for conceptual navigation through visualisations of knowledge.[54]

Ultimately this theme of globalisation and uniqueness needs to be extended to the realm of languages also. The same danger of a McWorld in terms of shapes is posed by the threat that we would have a McWorld where English was the only idiom of expression. Already, there are French critics who would have us dismiss the web because there is more English than French. With the advent of Unicode and important software such as the Tango Browser by Alis Technologies, over 90 languages are covered at present. This is, however, but a small fraction of the 6,000 languages presently in use around the world. Thus, added to the challenge of getting everything on line there is the greater challenge of getting it translated into as many languages as possible. Taken seriously, this challenge will take care of much unemployment.[55]

8. Learning

In light of the above some will no doubt agree that Negroponte was surely right in his description of a world where butlers will do our scholarly work for us. Others will at least ask: is there anything left to do? On reflection the answer is definitely, yes, there will be lots left for humans to do. Computers may be useful in finding *Virgins,* even valuable in finding their lower-case variants. However, this does not address the question of what to do when one finds them. New software may provide sense-making tools, but at a certain level the challenge of how to interpret the significance of what we find will always be an essentially human task. For in this task lies the realm of meaning which is central to being human.

To see this more clearly it is useful to recognise that the ten levels of knowledge in a library are also the ten areas of learning for an individual. Potentially they are also the ten areas of their scholarly activities. Learning in its deepest sense is about all levels of knowledge and about the process of organising all those levels into understandable patterns or more precisely patterns which increase our understanding and our wisdom. Seen in this way, it soon becomes clear that most of us have a very limited sense and also limited practice of learning. The interests of most persons and the work of most scholars belong to the third section of the library. We do internal analyses. How does that motor work? We do identifications and descriptions: What is that motor part? Who is that figure? What is that object? Where is that place? Or we do external analyses: Who is that figure related to stylistically or genealogically? What are other examples of that theme? Where are other paintings by the same artist, or similar paintings? Some of us do restorations. Some historians are particularly caught up with reconstructions. Most scholarship is secondary literature, commentaries on the deeds of others.

A minority of persons actually write books which belong to the primary literature section of the library. An even smaller minority write works which affect fundamentally the reference section of the library and paradoxically this is more true the further one ascends the levels of knowledge.[56] A certain number of persons (e.g. critics) produce partial contents of books (abstracts, reviews, citation indexes). A smaller number produce titles (librarians and cataloguers) or write standard encyclopaedias. Even fewer write our standard dictionaries and even fewer still affect the great classifications such as Library of Congress. It is perhaps no coincidence therefore that we frequently remember them in terms of their author's name: Bliss, Dewey, Ranganathan. And paradoxically there is an unexpected connection with getting back to that first level of knowledge and preoccupation with the first principles of knowledge in a philosophical sense that affects the very ordering of the layers. In this realm we find the philosophers, theologians and mystics who challenge us not just in terms of this or that interpretation or definition but rather in terms of our entire framework by which we understand who, what, where, how and why we are.

At the same time, the creation of terms, naming, organising them, making classifications is perhaps the most universal of all human activities. We all make lists to make sense of the world, to impose order on it. That is what the constructivists are on about. What they overlook is that most of us are too lazy to do this for purposes other than our purely personal satisfaction and we are quite happy to accept that someone else has taken the trouble to create a more universal scheme. A few of us make an effort to go beyond the accepted schemes. We name them thinkers and intellectuals. Only the rarest succeed in creating truly useful universally applicable schemes. Somehow it is only given to these few, an Aristotle, a Plato or a Leonardo, to propose an order worth remembering, worth trying to understand, worth trying to go beyond. We call them geniuses, spiritual leaders, wise men, shamans only confirming by our poverty of words our own distance from this category making transcendence.

9. Conclusions

Computers are transforming the meaning of education in the sense that most of the traditional drudgery of learning and scholarship can soon be delegated to electronic tools in anthropomorphized forms as aids, agents, avatars or even butlers. There is not a little irony in this trend. Nearly a half century ago visionaries such as Engelbart saw in computers a new hope for unleashing individual creativity. It was a noble goal based on a tantalising premise. If only we can provide everyman with the right tools then everyman can do anything. By this premise the word processor was to make everyman an author. Millions of copies of Word Perfect and Word have been sold. A corresponding surge of Nobel laureates in literature has not been evident. Similarly, millions of Computer Aided Design (CAD) packages have been sold, but not every owner of the software has become a great designer or a famous draughtsman. Soon there will be millions of video-editing packages, but the number of memorable video and film producers will not rise proportionately. Some will be tempted to dismiss this whole exercise as a mistake or see it as confirmation that commercial interests are truly the driving force behind these

developments. It may be more fruitful, however, to suggest that the experiment is unfinished because certain vital ingredients are still lacking.

Traditionally we learn best from example. There has been so much enthusiasm over the new tools that many assume or even believe that example is no longer necessary. This is reflected in catchy phrases such as: “From the sage on the stage to the guide on the side”, usually pronounced by key-note speakers who are very much centre-stage. More significantly it is reflected in the politics of our educational system. For example, in faculties of education even in major universities, those who are learning to teach may find no formal courses on computers, their uses or their implications, practical, or philosophical. As a net result, we end up with magnificent tools with practically no one around who is seriously equipped to teach their uses and potentials.

Instead, teachers are provided with all kinds of theories about what computers should do for children: how they should create computer supported intentional learning environments; help them to collaborate; encourage them to create their own categories, classifications, semantic networks and world-views; give them courage to construct their own knowledge frameworks and help them to assess each others’ efforts in all these endeavours.

As noted earlier these are very noble goals. They epitomise the achievements of the greatest scientists, philosophers and theologians of all time. Yet there are two fundamental differences between these great individuals of the past and our students of the present. First, these outstanding thinkers all had great teachers. Aristotle had Plato. Grosseteste, the founder of Oxford University, had Gundissalinus. Thomas Aquinas had Albertus Magnus. Yet we now expect our students to achieve great things without teachers. Indeed, we are giving them tools for manipulating words and images, tools for interpretation (part three of the library), before they have experienced the existence of solid facts (part two of the library), and without the help of all the traditional pointers to knowledge (the reference room which is part one of the library.

Second, with the great thinkers of the past there was an implicit assumption that one began by mastering the best which existed, and did not replace this until one and had achieved something which went further. Hence, in science it was useful to accept the categories of an Aristotle until a Leonardo could propose a more encompassing alternative. It was valuable to continue with the world-view of Newton until Einstein could offer a richer alternative. In the humanities generally, and in sociology and education in particular, the constraints of *more encompassing* and *richer* seem to have been forgotten. It is as if the simple act of making categories and theories, of constructivism were sufficient in itself, were virtue, as if the process were more important than the result.

If we are right, herein lie some of the deeper reasons for the discrepancies between the hype about multi-media and everyday practice; why the computer revolution, which has been imminent for so long is still only in its infant stages. We have been so busy creating the tools for the building that we temporarily forgot about the need for doors and

windows. We now need to apply these tools to all parts of our libraries, which are the collective memories of all our lives. We need to bring back into focus the example of the great minds who came before. We need to show students examples. For only if we learn to see how small we are in the aeons of achievement, will we ever have the humility to unleash the incredible potentials which these past periods offer for our future insights beginning now. And only then will computers truly transform the meaning of education.

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Notes

[1] See, for instance, Johanna Neumann, *Lights, Camera, War. Is Media Technology Driving International Politics?*, New York: St. Martin's Press, 1996.

[2] Cf. Ralph Nader, Vandana Shiva, Martin Khor, David Morris, Herman Day, Jerry Mander et al., *The Case Against Free Trade: GATT, NAFTA and the Globalization of Corporate Power*. Earth Island Press/North Atlantic Books, 1993; John Cavanagh and Richard Barnet, *Global Dreams: Imperial Corporations and the New World Order*, New York: Simon and Schuster, 1994; David Korten, *When Corporations rule the World*, West Hartford, CT: Berrett Koehler/Kumarian Press, 1995.

[3] For an important analysis of the present trends set in an historical context see: Armand Matellart, *Mapping World Communications, Minneapolis: University of Minnesota Press, 1994. Original: La communication monde. Histoire des idées et des stratégies*, Paris: La Découverte, 1991.

[4] See: http://www.infobyte.it

[5] These are: Library of Congress, Ohio Historical Society, Duke University, Harvard University, New York Public Library, North Dakota State University, Fargo; University of Chicago, University of North Carolina, University of Texas at Austin.
See: http://lcweb2.loc.gov/ammem/award and http://www.ameritech.com. In addition to these there are other initiatives at Carnegie Mellon and Stanford (cf. note below).

[6] It is noteworthy that these capabilities are still absent from leading commercial products today, although a number of high-level initiatives in the fields of design, architecture and

engineering are clearly moving in this direction. Autodesk for instance, has introduced the process of versioning in their AutoCAD software such that one can trace the evolution of a drawing or design and document who made what changes when. They have also introduced the notion of industry foundation classes. Hereby, a door is treated as an object (in the computer sense), such that a door for a cottage automatically adjusts to the features of a cottage door, whereas a door in a skyscraper will automatically take on the characteristics of a door in such a building. In the parlance of salesmen, the door "knows" the shape that it has to take on in different environments, i.e. it is a "smart door." In the past, one had to draw each door anew. Now one simply invokes the door (as a computer object) and it automatically becomes what it has to become (reminiscences of Aristotle's notion of entelechy).

[7] For more information on Engelbart's Bootstrap Institute
See: http://www.bootstrap.org.

[8] Howard Rheingold, V*irtual Reality*, New York: Summit Books, 1991.

[9] Howard Rheingold, *Virtual Community*, Reading, Mass: Addison Wesley, 1993.

[10] See Pierre Levy, *L'Intelligence collective, Pour une anthropologie du cyberspace*, Paris: La Découverte, 1995.

[11] The figures used in these examples make no pretence of trying to estimate true market value. The point of the exercise is to establish the scale of the enterprise.

[12] In this context, it is useful to recall the distinction made by Professor Dertouzos between information the noun and information the verb. Information the noun is the raw material: books, manuscripts and the like. Information the verb is the realm of interpretation: what we do with this material, the activities of knowledge workers. He estimates that information the noun is 10% of the economy and information the verb is at least 60% of the economy. Owning the manuscript is simple. Scanning it in is still relatively simple. Translating it is less simple. Understanding it is anything but simple.

[13] GNU stands for GNU not Unix. The idea is to create alternative to Unix utilities. Cf.: Aeleen Frisch, *Essential System Administration*, Sebastopol: O'Reilly & Associates, 1991, xvii.

[14] See: http://www.gamelan.com

[15] See: Rex Winsbury, ed., "Digital Terrestrial TV: Descrambling the Issues," *Inter Media Special Report*, London, vol. 25, no. 2, 1997.

[16] Cf. Jeremy Rifkin, *The End of Work: The Decline of the Global Labor Force and the Dawn of the Post Market Era*, Putnam, 1995.

[17] Hans Peter Martin, Harald Schumann, *Die Globalisierungsfalle. Der Angriff auf Demokratie und Wohlstand*. Reinbek bei Hamburg: Rowohlt, 1996. Cf. Horst Afheldt, *Wohlstand Für niemand? Die marktwirtschaft entlässt ihre Kinder*, Munich: Kunstmann, 1994.

[18] Among the pioneers was the late, Yuri Rubinsky who went on to become a founder of SoftQuad, and then died tragically at an early age.

[19] Dynamic HTML will not fully solve this conflation.

[20] See: http://www.infoseek.com

[21] See: http://arachnid.qdeck.com/qdeck/products/webcompass/

[22] See: http://www-diglib.stanford.edu

[23] Michelle Q. Wang Baldonado, "Searching, Browsing, and Metasearching with SenseMaker," *Web Techniques*, San Francisco, volume 2, issue 5, May 1997, pp. 43-47.

[24] Cf. Tom Davey, "Push meets Search," *Information Week*, Manhasset, 14 April 1997, p.72 describes three new packages Verity's Intelliserv, Excalibur's Profile and Fulchrum's Knowledge Network.'

[25] There will of course be exceptional occasions when such an exhaustive search is appropriate.

[26] See: http://mcf.research.apple.com

[27] See Ramana Rao, Jan O. Pedersen, Marti A. hearst, Jock D. Mackinlay, Stuart K. Card, Larry Masinter, Per-Kristian Halvorsen, George G. Robertson, "Rich Interaction in the Digital Library," *Communications of the ACM*, New York, April 1995, vol. 38, no. 4, pp. 29-39. Cf. Stuart Card, "Visualizing Retrieved Information", *IEEE Computer Graphics and Applications*, 1996.

[28] See: http://purl.org/metadata/dublin_core>

[29] See: http://www.dlib.org/dlib/july96/07dempsey.html>

[30] See the article by C. Lagoze and Clifford Lynch et al. with that title at: http://cs-tr..cornell.edu:80/Dienst/Repository/2.0Body/ncstrl.cornell%2ftTR96-1593/html.

[31] As in the case of all important topics, which have become buzzwords, the term is often used very loosely with no reference to the technical meanings of the term: e.g. the Meta Lab at the University of North Carolina. Even experts admit that they are frequently uncertain of what the term means.

[32] See: http://www.ewos.be/aegis/home.htm.

[33] Organised by the Association of Information and Image Management:
See: http://www.aiim.org/dma.

[34] See: http://www.cs.umbc.edu/agents/kse.shtml

[35] See: http://cs.umbc.edu/kqml

[36] See: http://logic.stanford.edu/kif/kif.html

[37] See: http://www.nbs.gov/nbii.

[38] See: http://www.cutech.com/newmeta.html.

[39] See: http://www.metadat.org.

[40] See: http://csvu.nl/~eliens/wwww5/papers/Meta.html

[41] See: http://www.lbl.gov/~olken/X3L8/activities.html

[42] See: http://www.llnl.gov/liv_comp/metadata/metadata.html

[43] See: http://www.parc.xerox.com/spl/projects/mops

[44] See: http://www.nlc-bnc.ca/ifla/II/metadata.htm>

[45] See R. V. Guha, "Meta Content Framework," *Apple Technical Report Note: 167*, Cupertino: Apple Research Laboratories, March 1997; R. V. Guha, "Meta Content Framework: A Whitepaper," *Apple Technical Report Note: 168*, Cupertino: Apple Research Laboratories, March 1997; R. V. Guha, "Towards a Theory of Meta Content," *Apple Technical Report Note: 169*, Cupertino: Apple Research Laboratories, March 1997.

[46] See Tsuyoshi Sakata, Hiroyuki Tada and Tomohisa Ohtake, "Metadata Mediation: Representation and Protocol," *The Sixth World Wide Web Conference Proceedings*, April 7-11, Santa Clara, 1997, pp. 49-59.

[47] It will be noted that these six natural components of a library comprise the first six levels of knowledge in the SUMS framework.

[48] At Wolfenbüttel, one of the greatest research libraries of the world, it was jokingly said that scholars spend 95% of their time finding a rare source and 5% of their time actually

reading it. In practice the mix depends largely on the level and kind of scholarship. If one is working on a new edition of a classic text such as Hamlet and one is using the accepted sources, then search time is limited to secondary literature. If one is trying to master a field, or determine the boundaries of a new field, then it could be as high as 95%. In many cases about a third to half one's time is also spent writing the results of one's readings.

[49] For another treatment of these problems see the author's "Frontiers in Electronic Media", *ACM Interactions*, New York, July 1997, (in press).

[50] Benjamin Barber, *Jihad vs. McWorld*, New York: Random House (Time Books), 1995. Some see globalisation as necessarily wrong and the local as an alternative: e.g. Jerry Mander, Edward Goldsmith et al., eds., *The Case Against the Global Economy: And for a Turn Toward the Local*, San Francisco: Sierra Club, 1996.

[51] These problems will be explored further in the author's essay, "Global Standardisation, Regionalism, and Individual Uniqueness", *Oz. Rivista internazionale di Utopie*, Rome, vol. 4, 1997, (in press).

[52] Michael Potmesil, "Maps Alive: Viewing Geospatial Information on the WWW," *Sixth World Wide Web Conference*, Santa Clara, April 1997, TEC 153, pp. 1-13.
Cf. mpm@research.bell-labs.com

[53] To give some idea of the immensity of material involved a one meter scale map of the United States requires 3,300 CD-ROMS or approximately 2,112,000 megabytes.

[54] One of the pioneers in this field is Stuart Card, as in note 28 above. Cf. *Proceedings of the Workshop on Advanced Visual Interfaces*, Gubbio, 1996. See, also the work of Heiner Benking (Ulm), who has been working on new spatial visualisations using a cognitive Panorama with a magic cube (ZauberWürfel) which serves as a "bridge between literal, figurative-metaphorical, contextual and physical landscapes of meaning, allowing us to share also information beyond meso-scale. Cf. his lecture " The Necessary next Phylogenetic Step—World View Compositions," Konrad Lorenz Institut, Altenberg/Vienna, 1997.

[55] Terralingua.
See: http://cougar.ucdavis.edu/nas/terralin/home.html

[56] It is also ironic that when persons active in authoring these first five layers become too energetic they resemble secondary literature.