Kim H. Veltman

New Media and New Knowledge

Proceedings of the Third Canadian Conference on Foundations and Applications of General Science Theory: Universal Knowledge Tools and their Applications, Ryerson, 5-8 June 1993, Toronto: Ryerson Polytechnic University, 1993, pp. 347-358.

---

1. Introduction

If we accept Marshall McLuhan's dictum that the medium is the message then the advent of computers will affect not only the speed with which we gain access to knowledge, but will also transform our sense of what it means to know. This is all the more true because unlike radio or television, which were discrete media focussing on specific senses, the term "computer" is actually a synecdoche, whereby a part stands for a whole range of electronic media. Among the few who are not just talking about but are exploring how multimedia can transform our approaches to knowledge, is Seymour Papert,[1] who believes that traditional emphasis on the three R's: reading, writing and arithmetic is outmoded and foresees a new visual approach emphasizing pictures rather than words, which will supposedly liberate us from the confines of "letteracy". Others speak imaginatively of "info-surfing hypertext keywords".[2]

In our view the consequences of the new media lie elsewhere. We begin by examining two short-term effects of computers: a new emphasis on pipelining and on brute force in a computational sense. A number of alternative models of knowledge are then reviewed. The latter part of the paper suggests that the deeper implications of computers lie in providing multi-dimensional access to domains and kinds of knowledge and in tracking abilities.

2. Pipelining and Process

Many recent discussions emphasize the importance of an electronic highway. Curiously these discussions seldom make reference to the digital equivalents of cars on this electronic highway. The emphasis is on pipelining without content. When one draws attention to this discrepancy, allusions are made to the farmer in *Field of Dreams* whose inner vision instructed him to build a baseball stadium in the middle of nowhere. His qualms about having spectators were resolved by a simple phrase: build it and they will come. The assumption is that the same will apply to content and users on the electronic highway.

Considerable energies are now being invested in the process of communication itself. The focus is not simply on the hardware that makes the pipelining possible, but on adaptations of both the hardware and software which will render the process more engaging and record the process. In projects such as Worldlinx's Vis-a-Vis this remains implicit. In the Telepresence project at the University of Toronto this goal is explicit. An aspect of the PARIS project at Ryerson attempts to document interaction between doctors, staff and patients. An IBM project (at Yorktown Heights), directed by Cathryn Wolf, termed the Window Environment Meeting Enhancement Tool (WE MET), has a similar aim: i.e. to record and document new types of interaction introduced by the latest media, rather than exploring the implications of these media for recording the entire scope of knowledge.

Among the few exceptions to this approach has been Professor Boulet's project at Laval University which entails three types of intervention, namely, an active mode, monitoring the user by checking errors; a passive mode, which waits for a request from the user and a pedagogical remedial teaching mode, which suggests books on the basis of wrong questions asked.

3. Computers as Number and Word Crunchers

Those who do use the new media to focus on content typically extend the notion of computers as number crunchers to include word crunching. Here the assumption is that since we have the power to index on any term, we no longer have to worry about what to index and what not to index. This has been explicit in visionary projects such as Ted Nelson's Xanadu.[3] At a more practical level this philosophy has guided recent software projects such as Freebase, Innotech's Findit software for CD-ROMs and is an underlying premise in Xerox's new Information Theatre.[4]

There are several problems with this approach. First, although very effective while the corpus remains within certain limits, when applied to large databases the user is overwhelmed by long lists of references. Second, it ignores the cultural contexts of words. A computer searching for instances of *excellent* would have no way of knowing that in Jutland and occasionally also in Scotland the term for *excellent* is "not bad". The word *cow* provides a less obvious example. It is easy to tell the computer that the English term *cow* can be translated into the French term *vache.* However, terms surrounding *cow* are often very negative as in "He was thoroughly cowed", whereas phrases linked with

vache are often extremely positive as in *vachement bien*. A word crunching search tool which expects one-to-one correspondences of terms may find the animals that produce milk but will overlook all the subtleties of positive and negative connotations associated with those animals, and likewise for other subjects.

Third, the word crunching approach ignores historical contexts whereby these cultural differences are compounded. Unless the computer is cold that the technical term for wine barrel measurement in sixteenth century English was gauging, it will find no material on this subject. For this reason I have argued elsewhere[5] that authority lists in isolation only close doors to the past. Each synonym, alternative term and variant spelling is a key to historical documents. Hence, if word crunching is to amount to more than simple brute force, cultural and historical contexts are vital and whoever ignores these is left with an artificial sense of knowledge which is why the concept of intelligent agents, be it in Negroponte's sense of an intellectual butler, or Laurel's sense of an invisible secretary, is ultimately naive.[6] To continue our case that the deeper implications of computers lie elsewhere will require a digression into alternative views concerning knowledge.

4. Knowledge as Objects and Substance

Within the Greek tradition, particularly through Aristotle, knowledge was mainly a challenge of definition focussing on the substance or quiddity of objects. Cassirer analysed this tradition in *Substance and Function*[7] which has provided a context for notions of a canon or corpus of knowledge: i.e. that there are a number of basic things mastery of which constitutes knowledge.

This approach to knowledge as something tangible is much more firmly rooted in some cultures than others. For example, in German the verb to know *(wissen)* is intimately connected with the noun for a field of knowledge *(Wissenschaft),* which in turn is inextricably linked with the noun for science (*Naturwissenschaft)* to the extent that the two terms are used interchangeably. The adjectives for scholarly and scientific are also covered by a single German term (*wissenschaftlich*) and the same word (*Wissenschaftsgeschichte*) is used for history of science and history of ideas.[8]

In French, by contrast, distinctions are made between official knowledge in the sense of power (*savior*) and subversive knowledge which criticizes power (*connaissance*).[9] In the United States there are distinctions between information: i.e. mere facts and knowledge. Meanwhile, in English, the *Oxford English Dictionary* attests that knowledge has as its first meanings, acknowledgment, confession and recognition of a position or claims. A second meaning entails knowing a thing, a state or a person, including acqaintance in the sense of intimacy. Theoretical or practical understanding of an art or science is a sixth and science is only included as a ninth connotation of knowledge. So the extent to which knowledge is appreciated as something concrete as opposed to being merely a viewpoint varies from culture to culture[10], changes historically, and is embedded in different languages.

5. Knowledge as Function and Abstraction

Even within the German tradition[11] which has nurtured a concrete sense of knowledge, philosophers such as Cassirer have argued that this approach was limited to Antiquity and the Middle Ages to be replaced in the Renaissance by a shift from substance to function, whereby knowledge became seen in terms of the relations between and among objects rather than through definitions of the objects themselves. This according to Cassirer was the context leading to the rise of early modern science.

A more radical expression of this approach claims that knowledge entails abstraction. In art, this approach. measures paintings in terms of their degree of abstraction: realistic paintings have some value, impressionistic paintings have more value and abstract paintings are the most advanced.[12] Implicit in this approach are assumptions about progress which scholars such as Gombrich[13] have challenged directly claiming that art entails a number of functions which cannot be reduced to a single, linear goal.

Nonetheless, the champions of this approach[14] would claim that progress is to be understood as a shift from perceptual to conceptual modes and emphasize developmental models of knowledge, frequently citing Piaget while leading in directions quite distinct from those of the Swiss experimental psychologist. In science, this approach implicitly holds that knowledge of an object has limited value; that a model of the object is better; a diagram better still and an algebraic (or chemical) formula constitutes so-called true knowledge. If one accepts this view then knowledge entails the equivalent of a distilling of matter until reduced to a .series of abstract formulae.[15]

6. Knowledge and Intelligence

It is instructive to look at a shift in emphasis from knowledge to a study of intelligence as another reaction against the tradition holding that knowledge is something concrete entailing a canon or corpus of basic works. Hence the focus is shifted away from knowing specific things to the method employed in acquiring knowledge; which emphasis on epistemology has led to discussions of methods, processes and strategies. For instance, Sternberg[16] identified no less than seven basic approaches to intelligence (figure 1).

It is striking how none of these seven alternatives focusses on tangible aspects of knowledge. This was also the case when Sternberg further distinguished among seven kinds of intelligences in his discussion of systems, namely, linguistic, logical-mathematical, spatial, musical, bodily kinesthetic, interpersonal and intra-personal,[17] although it could be argued that spatial intelligence is at least potentially tangible when seen in terms of geographical information Systems (GIS), an aspect not considered by Sternberg.

Geographic	Spearman, Thurston, Guilford, Cattell-Vernon
Computational	Hunt, Sternberg
Biological	Levy, Jensen, Eysenck
Epistemological	Piaget
Anthropological	Berry, Cole, Charlesworth
Sociological	Vygotsky, Feuerstein
Systems	Gardner, Sternberg

Figure 1 Seven models of intelligence according to Sternberg (1990).

7. Knowledge as (Social) Construction, Deconstruction and Reconstruction

Meanwhile, other recent trends focus on the importance of social context which, in terms of Sternberg's categories, entail the final two of the seven intelligences, namely, interpersonal and intra-personal. At the same time this clearly reflects some strands of Marxist interpretation[18] and attempts to integrate the role of human interests into our conceptions of knowledge.[19]

Sometimes linked, but frequently treated independently are trends that view all knowledge as con-, decon- or reconstructed. In these approaches words are effectively deceptive surfaces which need to be taken apart and pieced together anew before their meanings can be gleaned and even then there is no fixed meaning to be discovered. It is assumed that each person, especially a member of a minority will discern an independent and unique interpretation.

Those who emphasize social aspects of knowledge frequently play down the significance of book learning while focussing on oral methods, direct communication and the potentials of networks[20] where there is no clearly defined static corpus of knowledge. Hence this approach also reflects certain media in particular contexts.

8. Verbal and Visual Knowledge

Implicit in Sternberg's concept of seven intelligences has been the notion that some are basically verbal and numerical (logical-mathematical intelligence), while others are more visual (spatial intelligence). Psychologists such as Arnheim,[21] have even claimed that all thought is visual. While such a radical claim seems clearly untenable there are important trends to suggest that this is equally the case with respect to arguments for a progressive abstraction in the sense mentioned above. Practical inventors such as Sutherland[22] or Robinett[23] and mathematicians such as Mandelbrot[24] have drawn attention to the need for visualizing in domains not usually within the scope of human vision, which has led to the growth of a new field of scientific visualization and generated popular picture books.[25]

At a deeper level there has been a growing recognition that earlier models which saw science in terms of progressive abstraction and epitomized by abstract formulae, were one sided at best; that the formulae in isolation are frequently incomprehensible and hence that knowledge resides less in the abstract or concrete ends of the Spectrum but

rather in the systematic correlation of various stages in between. Hence just as systematic scale brought a new coherence to geography, systematic scales of abstraction (and concreteness) will potentially bring a new integration to concepts of knowledge [26]

9. Enduring and Ephemeral Knowledge

There is a further distinction to be made between enduring and ephemeral knowledge. The proponents of enduring knowledge focus on knowledge as objects and substance, on things which do not change in essence. They will be careful archaeologists, studying the ruins in order to discover the eternal harmonies represented by the Parthenon or the Roman Forum. They are very much concerned with the time and history as means of keeping alive a continuity through careful study of records written, constructed and depicted. They therefore emphasize the role of documents and sources, the importance of languages and the need to study the originals, because there is something unchanging and unshakeable in these originals.

Others focus on the ephemeral, on the fleeting moment and strive to experience its magic. This quest leads to a concern with performance, with the spontaneity of a passing event. This tradition emphasizes the importance of the social, the psychological, the significance of human intervention at the moment, hence the role of constructivism, deconstruction, reconstruction, all forms of interpretation and hermeneutics and downplays the value of anything enduring. Ironically since the arrival of new methods for recording the fleeting moment in the twentieth century there has been a remarkable attention to create enduring films, records, and more lately CD-ROMs of their performances. History in this context is used to emphasize the passing nature of things: so one would use it to point out how the Parthenon has become a ruin over time rather than emphasize its timeless harmonies. This approach will downplay the role of documents and sources, the importance of languages, the significance of history because they are concerned primarily with the now. Often this approach emphasizes the importance of abstraction, knowledge as a formula or as a container (pipeline) rather than content.

10. Knowledge as Domains and Levels

But, the patient reader may ask, what has the above excursus into various interpretations concerning knowledge to do with the advent of computers? How will the new media change the messages and transform our approaches to knowledge? A first answer is found in the concept of domains and levels[27] of knowledge. Many seeming oppositions and contradictions between kinds of knowledge resolve themselves if one recognizes that knowledge has at least three basic domains which may be characterized as pointers, objects and insights. Pointers are so called because they point at knowledge in the form of objects. They are tools, usually reference works that we use to search for knowledge. These range from classification systems, which provide lists of terms or subjects; dictionaries, which define the terms; encyclopaedias, which explain those terms; bibliographies, which provide lists of titles, and partial contents such as abstracts, tables of contents and indexes, which give some initial description of the contents of articles and books.

In the past materials in all five of these levels were published in different books and stored in separate places. The new media will integrate disparate facts from these different levels within a single coherent framework. It will be noted that those who emphasize knowledge as definition are sometimes explicitly concerned with dictionaries (level 2) and may implicitly include all five layers of pointers.

These above-mentioned pointers serve as introductions to a sixth level which deals specifically with knowledge as objects, namely, reproductions in facsimile of the natural world (animal, mineral, vegetable), the man-made world (books, paintings, buildings, instruments etc.) and situations where the natural and man-made world are inextricably linked, as is the case with environmental issues. Those who emphasize knowledge as objects and substance usually focus on material in this sixth level and sometimes include materials from the five levels of pointers. In the parlance of some, these levels would constitute public knowledge which they distinguish sharply from personal knowledge.

Personal knowledge in this sense is quite distinct from the way it was used by Polanyi[28] in his seminal book. There it was used to explore how a scientist's personal commitment, belief, and conviction were integrally connected with a quest for objective facts in science. Now it is frequently used in a much looser sense to refer generally to realms of knowledge that are open to interpretation. This third domain of knowledge has various names. It is the domain of insights,[29] analysis, interpretation and hermeneutics.

As in the domain of pointers, this realm readily lends itself to further division into internal analysis, external analysis, restorations and reconstructions. If these are added to the levels outlined above they constitute levels seven to ten. Those who emphasize knowledge as construction, deconstruction or reconstruction are usually referring to level ten in particular and sometimes levels seven through ten, with such enthusiasm as to forget that levels one through six remain a necessary point of departure. Similarly those who emphasize intelligence rather than knowledge are usually referring to the methods underlying levels seven through ten, although the search strategies required in dealing with pointers (levels one through five) also deserve inclusion.

The simplest type of interpretation, internal analysis focusses on the object itself. In the case of literature this is sometimes termed close reading. Involved are attempts at identification and description which though theoretically straightforward, frequently prove enormously difficult. Classical allusions or references to mediaeval philosophers are cases in point.. Not everyone will have uppermost in their mind the considerable differences between Scotus Erigena and Duns Scotus. In the medium of books learned footnotes have traditionally served to bridge gaps between a major author's erudition and a minor reader's lack thereof. (Fashion may dictate that we emphasize the significance, importance and even the nobility of the underprivileged and minorities but ultimately even fashion cannot do away with the problems of those who have not done their homework). A book which attempted to explain every allusion systematically would be so footnote heavy as to be effectively unreadable.

Here the new media offer new possibilities. The simple use of hotwords means that experts can read the text in an unobstructed form, while less expert readers are free to consult terms at will. If one adds to hotwords a principle of different levels of access which we have described elsewhere as an accessometer,[30] then readers can decide for themselves the depth to which they wish to pursue these links. From the viewpoint of the system as a whole, level seven establishes links between names found in the full contents of books (level six), definitions (level two) explanations (level three). This can be automated. A reader will then be able to decide whether they are content with a minimal description of Zeus as a chief god who was the Greek equivalent of the Roman Jupiter; whether they wish to read a fuller description in Bullfinch's *Mythology* or whether they require a thorough scholarly account such as that found in Pauly-Wissowa's *Reallexikon fur Altertumswissenschaft.* Of fundamental significance is that a reader can change levels of access at will as they proceed. Books were necessarily written for a given readership or audience as they say.

The new media can integrate various levels simultaneously, which makes all the more sense because persons invariably have areas of expertise. A classical scholar will presumably need to look up fewer classical allusions, but will predictably need to look up more references when reading the Church .fathers or a modern play.

The implications of the new media are equally dramatic in the case of external analysis (level eight) whereby objects and persons are compared, contrasted and related to other objects and persons. In the past this occured whenever an individual made a connection between a figure in one book and a figure in another, between one drawing or painting and others with the same theme or of the same school; traced the development of a painting, or explored links between practice and theory, abstract-concrete, or universal-particular. Typically these were presented as isolated sequences in obscure articles. With the new media these can be integrated in a coherent system.

In the case of restorations, interpretations have been made by a restorer even before a scholar attempts to analyse the work themself. Hence restorations are treated as separate from and below internal and external analysis as a ninth level. Here again there are ways in which the quantitative capacities of electronic media have qualitative implications. In the past the sheer difficulties of recording proposed and actual changes were so over-whelming that most restorers simply relied on their memory. The advent of high level photography meant that each stage in the process of intervention could be recorded.

Adaptations of the tools used for computer aided design (CAD) have meant that various alternative proposals for restoration can be considered and compared before actual intervention occurs.[31] In the case of reconstructions an even greater degree of interpretation has occured before a researcher attempts their own analysis of the object or site and hence these are again treated as separate from and below the others as a tenth level of analysis.

Pointers	1. Classifications
	2. Definitions
	3. Explanations
	4. Titles
	5. Partial Contents
Objects	6. Full Contents
Insights	7. Internal Analysis
	8. External Analysis
	9. Restorations
	10. Reconstructions

Fig. 2. Three basic domains and ten levels of knowledge.

Levels of knowledge (fig. 2) in the sense used here entail something quite different than an artificial hierarchy. For while it will often be the case that a reader moves vertically down the levels from a subject term (level 1) to its definition (level two), explanations (level three), titles (level four) and so on, assuming that they know what they are looking for, they are perfectly free to go straight to a reconstruction (level ten).

This framework has become the starting point for a project sponsored by the Buro voor Systeemontwikkeling (BSO/Origin) and the Canadian Heritage Information Network (CHIN) at the Perspective Unit (McLuhan Program, University of Toronto) termed a System for Universal Media Search (SUMS).

11. Quantity and Quality

While it may not be popular to say so, there are ways in which quantitative considerations have qualitative implications. Most books are severely restricted in size and are consequently equally restricted in scope. Hence, a good book typically articulates one approach to knowledge to the exclusion of others. Once this restriction of size is removed as is the case with a CD-ROM or with a large hard-disk, so too is the need to limit oneself to a single approach to knowledge. At present these limits are typically in terms of hundreds of megabytes, but this is rapidly changing. A project at Computer Aided Televideo (CAT) Benelux is cataloguing all European patents on CD-ROMs connected in a juke-box environment to give direct access to 3.2 terabytes. The emergence of new holographic storage methods promises to transform completely the storage capacities of computers in the next generation.

Within this larger framework new links can be made between what appeared opposed views of knowledge. The domains of pointers and objects can be related to knowledge as objects and substance, to both verbal and visual knowledge and to enduring knowledge. The domain of insight can be related to knowledge as function and abstraction, to knowledge as social, to an emphasis on construction, deconstruction and reconstruction; to knowledge as experience and knowledge as ephemeral, and to trends which emphasize the role of intelligence over knowledge: process over content.

Quantity alone cannot bring quality into focus. But when used to integrate different domains and levels of knowledge, the vast storage capacities of the new electronic media offer a means whereby the complementary value of the enduring and the ephemeral, the spontaneous and the eternal can be related. It is possible to combine the archaeological, historical facts of the Parthenon to study both its enduring characteristics and the non-enduring realities of its decay. In this integration lies a key to keeping intact cultural and historical differences. What had been exclusive boundaries can now become inclusive horizons. In this sense rather than Evolution is embracing not replacing.

This takes us to the threshold of a complex problem which cannot be resolved within the scope of this paper, yet needs to be broached. The emphasis on abstract formulae, on containers rather than content sometimes represents a quest for the enduring rather than a commitment to the ephemeral; guided by a belief that if only one had the principles one would know the rules governing applications. In this sense the domain of pointers includes not only the material world (Popper's first world) but also the world of propositions, truths and standards (Popper's third world),[32] which is seeks to provide a framework for content, yet is transformed as the scope of the contents alters significantly, such that the would be enduring containers are reduced to interim models. Many of the discussions of paradigm shifts inspired by Kuhn[33] use this as a point of departure for claims that all is relative, that knowledge is merely consensus and opinion. This is highly misleading.

The gradual shift from a Ptolemaic to a Copernican model of the universe was a change in framework but the basic facts about the positions and orbits of the stars did not change. If we distinguish clearly between observations, and explanations of the observations the history of astronomy need not throw us into ab abyss of relativism. The challenge is to remain aware that there are various claims and explanations which pose as if they were enduring truths when in fact they are simply interim models. If the veridity and truth value of propositions can be established and if they are placed within the correct domain, there would be less futile debates concerning knowledge. Here again the quantitative scope of computers which allow all these domains to be accessed, related, compared and assessed should make a qualitative difference. Instead of reading about only one approach, the user will be able to study various contenders.

12. The Role of Tracking

From the above it is clear that the appropriate search strategy is a function of the quantity of knowledge being considered. If the material at hand is discrete and clearly defined, it makes eminent sense to use the word crunching method. If much greater quantities of material are entailed this would generate too many hits so one needs strategies to identify different domains of knowledge, namely, pointers, objects and insights, and various subsets thereof in terms of levels of knowledge.

The success of this second method depends also on the knowledge of the user, and more specifically on their awareness of precisely that which they wish to find. If a user knows that they want to find copies of Leonardo's *Mona Lisa* produced between 1510 and 1600

in France some careful searching will produce results. In the case of research, however, one typically does not know the precise questions to ask. One may be interested in religious reform in Germany between 1550 and 1570 or political reform in France between 1830 and 1860, but not know the names of the persons who were involved, let alone their particular actions and writings which are worthy of deeper study.

In such cases a third, exploratory strategy is required, whereby a person will follow one lead, find themselves going back to something they found earlier and then going deeper again. Such an approach will be much more effective if there is a tracking device recording various steps the person has taken, so that they can retrace these steps and indeed use their questions to create the equivalent of mental maps of their search strategies. Hence there are at least three different strategies depending on the stage of research and on the quantity of material being considered. Knowledge Engine, a project at the McLuhan Program in conjunction with Greenfield Associates will offer a model for this third type of strategy.

13. Editing and Non-Integrity

An attempt to assess the consequences of the new media on our understanding of knowledge would not be complete without reference to certain inherent dangers. Earlier media such as manuscripts and printed books had a tacit commitment to fidelity and integrity of the text. Indeed the whole point of tradition was to copy and hand down an earlier corpus as accurately as one could.

Many popular software products for computers, especially in the realm of multimedia, have a radically different goal. Indeed they focus attention on new means of editing, altering and even transforming original texts and documents. In a sense this is the function of all word processing tools such as Microsoft Word or Word Perfect. It is even more so in the case of packages such as Corel Draw which enable the user to do more dramatic and more subtle editing, such as changing the orientation of letters, altering their scale or even their kern. In the realm of video, products such as the Video Toaster entail equivalent functions. From the point of view of production all this is wonderful because it introduces an enormous range of new creative possibilities and hence software producers justifiably see themselves challenged to offer each new version with a volley of new features which can range from ten to well over a hundred.

From the point of view of knowledge organization these developments can readily be seen as a threat. Indeed potentially their consequences could be disastrous. For there is a striking disparity between the ease with which the new tools allow us to edit, alter or transform texts or images and the lack of effective means to document change. We have buttons to delete, replace, undo and morph but no methods to document how an earlier ediiton evolved into our new edition, how our first draft of a new article became our final paper. Hence software packages presently have a built in destruction of the stages of artistic creation, unlike writing which forced an author to go through several drafts each of which recorded physical stages of the articulation process.

This feature could readily be included in the electronic media. At one level it simply requires a save function which records different drafts independently rather than simply overwriting them each time. At another level it requires methods for identifying different generations of versions of images: i.e. which will distinguish between a direct photograph of the *Mona Lisa,* photographs of photographs and images which have been edited either in the sense of simple enhancement or deliberately changed. These problems are of course not new. They are familiar to all historians who have been confronted with engravings in different states.[34] And indeed, aside from their unconscious errors of haplography and the like, the mediaeval scribes were conscious of the possibility of editing their new electronic media, whether we use buzz-words such as multi-media or simply call them computers deserve to be seen as new ways of understanding the contexts of knowledge and providing new ways of knowing.

McLuhan Program, University of Toronto, May 1993

Notes

[1] Seymour Papert, "Obselete skill Set: The 3 Rs. Literacy and Letteracy in the Media Ages", *Wired,* San Francisco, vol. 1, no.2, May-June, 1993, pp. 50-52.

[2] Joe Flower, "What's a 3-DO?", *Wired,* as above, p. 68.

[3] Theodor Holm Nelson, Literary *Machines,* San Antonio, Texas: T.H. Nelson, (1981), 1987.

[4] M. A. Clarkson, "The Information Theatre", Byte, vol. 17, no. 12, 1992, pp.145-152.

[5] See the author's "Past Imprecision for Future Standards: Computers and New Roads to Knowledge", *Computers and the History* of Art, London, 1993, (in press).

[6] Cf. Brenda Laurel, *Computers as Theatre,* Reading: Addison-Wesley, 1991.

[7] Ernst Cassirer, *Substance* and *Function,* trans. W.B and M.C. Swabey, New York: Dover, (1923), 1953.

[8] Professor Burckhardt's paper elsewhere in these proceedings offers an excellent example of the continuity of this tradition.

[9] See Henri Lefebvre, *The Production of Space,* trans. Donald Nicholson Smith, Oxford: Blackwell, 1991, pp. 10-11, 367-368.

[10] For an attempt to retain some sense of truth in knowledge see Sir Karl Popper, *Objective Knowledge. An Evolutionary Approach,* Oxford: Clarendon Press, 1972. Cf. *criticism and the Growth of Knowledge,* ed. Imre Lakatos and Alan Musgrave, Cambridge: Cambridge University Press, 1970, particularly pp. 92-93.

[11] For a more recent assessment of these discussions in Germany see Gerhard Vollmer, *Was können wir wissen?,* Stuttgart: S. Hirzel Verlag, 1985-1986, vol. 1-2.

[12] Cf. Sidney J. and Ethel Blatt, *Continuity and Change in Art: The Development* of *Modes* of *Representation,* Hillsdale: Lawrence Erlbaum, 1984.

[13] Sir E. H. Gombrich, *The Ideas of Progress and their Impact on Art,* New York: Cooper Union School of Art and Architecture, 1971.

[14] . Blatt, as in note 6 above, provides a useful survey of literature in his opening chapters.

[15] See for instance: Gerald Holton, *Thematic Origins of Scientific Discovery,* Cambridge, Mass: Harvard University press, 1973. It is striking that this approach to knowledge as abstraction downplays the importance of a careful 'historical presentation. The essence can presumably be gathered from key insights devoid of either cultural or historical

context. Also instructive is Arthur I. Miller, *Imagery in Scientific Thought,* Cambridge, Mass.: MIT Press, (1984), 1986, which despite its title is concerned with the importance of abstraction in science.

[16] Robert J. Sternberg, *Metaphors of Mind. Conceptions of the Nature of Intelligence,* Cambridge: Cambridge University Press, 1990.

[17] Ibid, p.264.

[18] For an introduction to this literature see Leonard Goldstein. *The Social and Cultural Roots of Linear Perspective.* Minneapolis: MEP Publications. 1988. (Studies in Marxism. vol. 22).

[19] For an introduction to this literature see: Jürgen Habermas. *Knowledge and Human Interests.* trans. Jeremy J. Shapiro. Boston: Beacon Press. 1971. based on the original *Erkenntnis und Interesse.* Stuttgart: Suhrkamp Verlag. 1968.

[20] Cf. *Social Structures. A Network Approach.* ed. Barry Wellman and S. D. Berkowitz. Cambridge: Cambridge University Press. 1988.

[21] Rudolf Arnheim. *Visual Thinking.* Berkeley: University of California Press. 1969.

[22] Ivan E. Sutherland. "The Ultimate Display". *Proceedings of the IFIP Congress.* 1965. pp. 505-508. 23.

[23] Warren Robinett. "Electronic Expansion of Human Perception". *Whole Earth Review,* May 1991. pp. 1-8.

[24] Benoit B. Mandelbrot, *The Fractal Geometry of Nature.* New York: W. H. Freeman. 1977.21.

[25] E.g.. Alex Pomasanoff. ed.. *The Invisible World.* London: Seeker and Warburg. 1981 or Jon Darius. *Beyond Vision.* Oxford: Oxford University Press. 1984.

[26] See for instance the author's "Visualization and Perspective". *Leonardo e l'eta della ragione.* ed. Enrico Bellone and Paolo Rossi. Milan: Scientia. 1982. pp. 185-210.

27. Students of trends in knowledge organization will be aware of curious paradoxes in recent developments. On the one hand, the advent of Ranganathan's faceted approach to knowledge in terms of colon classification has inspired new attention to the potentials of thesauri with clearly defined hierarchies of terms. At the same time terms such as hierarchies. levels and even structures have become all but anathema because they are associated with a regimentation of the spirit that is seen as resbictive or simply false in that it imposes artificial frameworks on basic facts.

[27] . Students of trends in knowledge organization will be aware of curious paradoxes in recent developments. On the one hand, the advent of Ranganathan's faceted approach to knowledge in terms of colon classification has inspired new attention to the potentials of thesauri with clearly defined hierarchies of terms. At the same time terms such as hierarchies. levels and even structures have become all but anathema because they are associated with a regimentation of the spirit that is seen as restrictive or simply false in that it imposes artificial frameworks on basic facts.

[28] Michael Polanyi. *Personal Knowledge.* Chicago: University of Chicago press. 1958.

[29] Cf. Bernard J.F. Lonergan. *Insight.* San Francisco: Halper and Row. 1958.

[30] See the author's "Electronic Media and Visual Knowledge". *Knowledge Organization.* (formerly *International Classification.* Frankfurt, vol. 20, no. 1. 1993. pp. 47-54.

[31] The most impressive programme to date known to the author is that designed by Chimenti and Menci for the restoration of the chapel with the *Legend of the True Cross* by Piero della Francesca in San Francesco. Arezzo.
[32] For an introduction to these terms see Lakatos. as in note 8, p. 180.
[33] Thomas Kuhn. *The Structure of Scientific Revolutions.* Cambridge Mass.: M.I.T. Press. 1962.
[34] For an introduction to these problems see: William M. Ivins. Jr.. *Prints and Visual Communication.* Cambridge. Mass.: *Ml.T.* Press. 1953.