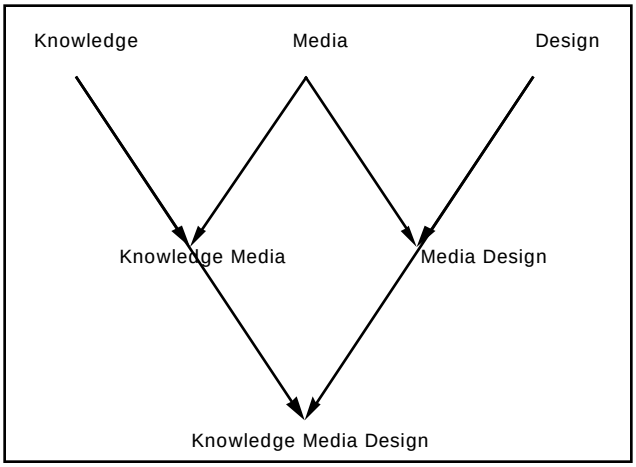
The Web of Knowledge Media Design

Highlights of a speech
given by Professor Ron Baecker
Director, Knowledge Media Design Institute
On 23 January 1997 at the OISE Auditorium
Toronto, Canada

...It's a great pleasure to be here today, to launch the Knowledge Media Design Institute (KMDI), an important initiative for the University of Toronto, for Toronto, and for Canada.

Knowledge Media Design. An intriguing, but mysterious phrase, apparently consisting of 3 nouns. But what's so mysterious? Just *what part* of knowledge media design don't we understand? Knowledge? Media? or Design?

Although knowledge media design is **not** a household word, roughly 50 accomplished U of T scholars and researchers have become very excited about this phrase as the name for a shared vision of how technology and new media can help us communicate, learn, think, create, and grow. This lecture series will communicate the excitement and the vision; today begins the process.



I will start by exploring interpretations of these three words, knowledge... media... and design. I will speak about *knowledge media* and *media design*, and then use the insights from these discussions to sketch a vision of a new discipline of *knowledge media design*. I will use the World Wide Web as a source of examples, and will draw liberally from the rich corpus of relevant work at U of T, thereby also serving to ground my closing remarks about KMDI.

So let us begin with the word "knowledge."

1. Knowledge

The 1971 Compact Edition of the Oxford English Dictionary includes 16 definitions of the word "knowledge," (see esp. #9, 10, 11, 13, 14). Most useful are the phrases: "truths, facts, or principles... information acquired by study... learning... erudition...the sum of what is known,"

David Perkins, in his thoughtful book *Knowledge as Design*, states:

> *"I construe knowledge broadly, including facts, concepts, principles, skills, and their intelligent, insightful, and sensitive use. I have in mind active knowledge that one thinks critically and creatively about and with, not just passive knowledge that does little but await the final exam."*[1]

Knowledge is not just data. It arises as part of a progression. We can imagine, as Bob Logan will do in his forthcoming book, *End of the Information Age*,[2] a progression beginning with *data*, leading to *information*, leading to *knowledge*, eventually leading to *wisdom*. Let's look at examples from two different domains — chemistry and graphic design.

Early chemists, such as Boyle, Cavendish, and Priestley, began in the 17th and 18th centuries the transition from alchemy to chemistry as a quantitative science based on empirical *data*. Lavoisier, Dalton, Avagadro, and others in the 18th and 19th centuries systematized *information* about elements, atoms, and molecules. Key to their work were novel methods of representation — chemical symbols, formulas, and equations. In the second half of the 19th century, Mendeleev and others brought order out of the chaos via what is now known as the periodic table — a remarkable encapsulation of a body of chemical *knowledge*. This in turn allowed chemists of the late 19th and the 20th centuries the *wisdom* to predict elements heretofore undiscovered, and, in many cases, to apply chemistry for human purposes.[3]

Now consider how graphic design begins with *data* about type of varying point sizes, styles, and weights. Design courses impart *information* — principles for the appropriate use of type. These principles are occasionally systematized into *knowledge*, such as the comprehensive graphic design and information display theories of designers such as Bertin,[4] Tufte,[5] and Marcus.[6] The widespread availability of desktop publishing technology has been excellent, but one downside has been fontitis, the *unwise* use in a single image of every weapon in the typographic arsenal. We'll look at examples of this later in the talk.

Knowledge is abstracted, structured, and organized information. The structure may be expressed as:

- a system of organization, like the Periodic Table, or
- a mathematical description, like the laws of quantum mechanics, or
- in a seminal text, such as those mentioned above, or
- as computer programs, such as simulation models that embody our understanding of phenomena like the weather or traffic.

Knowledge is not absolute. It evolves as we research and investigate phenomena previously unexplored. Good examples are found in the history of chemistry, and in the transition from Newtonian physics to quantum mechanics.

Knowledge is information that is developed and shared and enhanced by communities of individuals, a theme to which I shall later return.

Finally, as Donald Schön has asserted beautifully in his books on "The Reflective Practitioner," and will discuss here three weeks from now, useful knowledge may be tacit, not easily expressed or formalized, but nonetheless possessed by and exhibited in the behaviour of skilled practitioners. He speaks of:

"the reflection-in-action (the 'thinking what they are doing while they are doing it') that practitioners sometimes bring to situations of uncertainty, uniqueness, and conflict."[7]

Next, let us look at the word "media."

2. Media

The OED includes 9 definitions of the word "medium," (see esp. #4, 5). Of particular interest are the phrases "enveloping substance...through which impressions are conveyed to the senses..."

Toronto's own Marshall McLuhan is a better source of insights into the word "media." In *Understanding Media*, he writes:

*"... **the medium is the message.** This is merely to say that the personal and social consequence of any medium — that is, of any extension of ourselves — result from the new scale that is introduced into our affairs by each extension of ourselves, or by any new technology."*

"All media are active metaphors in their power to translate experience into new forms."[8]

He amplifies these ideas in *The Medium is the Massage* :

*"**All media are extensions of some human faculty — psychic or physical**. All media work us over completely. They are so pervasive in their personal, political, economic, aesthetic, psychological, moral, ethical, and social consequences that they leave no part of us untouched, unaffected, unaltered. **The medium is the massage**. Any understanding of social and cultural change is impossible without a knowledge of the way media work as environments."*[9]

Media are pervasive. For example, in *Understanding Media*, McLuhan presents a long and impressive list, shown on the slide, rearranged for clarity and effect:

- The spoken word, written word, printed word
- Print, comics, photographs, press, ads, games, movies, radio, television
- Telegraph, typewriter, telephone, phonograph
- Number, money, clocks, automation
- Roads, wheels, bicycles, airplanes, motorcar, weapons
- Clothing, housing

We look forward to hearing the McLuhan Centre's Derrick De Kerckhove on March 13.

Media are not passive transmitters of information, but are active agents of change for those who use them. A good example is the technology of document processing, which has fundamentally changed how many of us write. In preparing this paper, I was able to work both top-down in terms of an outline embodying the hierarchical structure of the argument, and bottom-up, importing definitions, quotes, ideas, and notes to myself as I developed and refined this speech over several weeks. The accompanying audio-visual presentation is another medium. Developing this in parallel with the speech allowed me to see the material in new ways and assisted greatly in idea formulation, and hopefully also in your appreciation and comprehension of them. Finally, although I'm getting ahead of myself, use of the "global digital library" known as the World Wide Web enabled me to access sources and images representing other people's work with unparalleled speed and fluidity. [A momentary personal digression.]

Digital media are particularly powerful embodiments of knowledge. In his recent book, *Being Digital*, Nicholas Negroponte persuasively describes the profound transformations associated with the transition from media based on *atoms* to media based on *bits*. Negroponte argues that "the medium is no longer the message."[10] He uses the example of a computer model of the weather, and notes that individuals can view it in many forms, such as a voice speaking the weather with intonation, a static diagram with illustrations and annotation, such as the one shown here, or an animated diagram using colour and motion. The particular form, or medium, in which you view and perceive it can be chosen at will and created on the fly by a many different virtual machines all capable of interpreting a common underlying digital model of the weather.

The fidelity and effectiveness of these representations, these new media, is a matter of "design," so let us now turn to this third, and final, basic word.

3. Design

The OED includes 24 definitions of the word "design," (see esp. #8, 10, 14c). Most relevant are the phrases "to form a plan...to purpose or intend (a thing) to be or do (something)..."

Perkins notes succinctly and eloquently that "design refers to the human endeavor of shaping objects to purposes."[11]

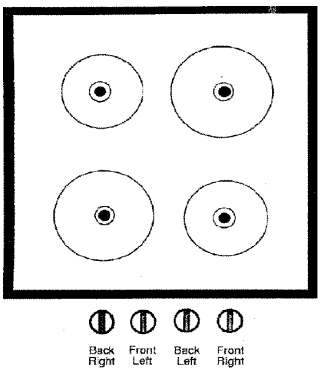
The historian of technology Henry Petroski has analyzed many examples of good designs, from paper clips and beverage cans to airplanes and bridges.[12] Good design considers *both form and function* together. The lesson has been learned by high technology industries, where graphic and industrial designers, artists and illustrators, animators and sound designers, now participate in producing artifacts with rich functionality that are also, in theory, attractive, easy to learn, and easy to use. Here are some examples from the firm Frog Design.[13]

Don Norman is an eminent cognitive scientist and was until recently the head of Apple's research lab, which in itself speaks volumes about the importance of human purposes in design. He has catalogued many cases of poor design, where human capabilities and purposes have been forgotten or subverted. He speaks eloquently about the glib concept of "human error," and about the need for designers to own up to their responsibility for guaranteeing that errors are impossible or at least much more difficult to make.[14] Let's hear Don on the concept of "technophobia."

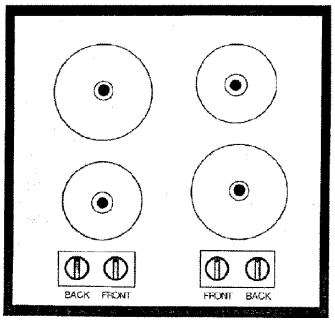
(At this point, a video clip of Don Norman was played.)

A good low-tech example of what Norman and others call user-centred design comes from the domain of design of stove controls.[15]

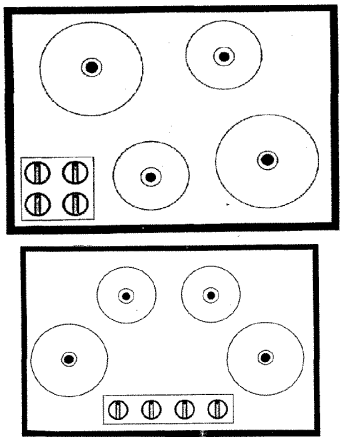
From the audience, someone tell me what is problematic about this arrangement of stove burners and controls:



Here's another example. What's the problem here?



Here are two more designs. Why are these better?



As in chemistry, where notations, formulas, and equations facilitate thought and the development of knowledge, representations are important in design. We'll return to this point later in the talk.

Good design, especially of complex software to be used by various individuals for many tasks in many work environments, cannot be created by inspiration, analysis, and pure thought alone. Novel representations emerge in working with the material, whether analog or digital, whether scientific or artistic. Gould and Lewis were the first of many to argue that human-computer interaction design must be *iterative*, with successive stages of conception and design, creation of mockups or prototypes, and user evaluation and testing, followed by more rounds of design, prototyping, and evaluation.[16]

Good design is restrained. Less is more. The disease of fontitis was present in 2 proposals I received for the advertisement for this lecture.

Happily, I later found a designer who produced the elegant work in the third slide.

Through the magic of digital technology, we can design configurations of data and information, as well as media through which the information can be perceived and interpreted. Perkins suggests that we consider knowledge not only as (structured, processed) information but also as design, as "structures adapted to a purpose."[17] This brings us to the concept of "knowledge media."

Let's review at this point...knowledge... media...design...

4. Knowledge Media

Knowledge media are documents, artifacts, technologies, and systems intended to enhance human creativity, learning, and knowledge building. We think, communicate, learn, and create using knowledge media. Classical examples include encyclopedias, textbooks, lectures, museums, Newton's Laws, the works of Mozart, and Bibles and commentaries on them. Telephones and even comic books are sometimes knowledge media.

We are, however, chiefly interested in a new and expanding category of knowledge media, those that incorporate interactive computer and communications technology. Examples of these include

- the World Wide Web and Web-based university courses
- HyperCard, Lotus Notes, and group decision support systems
- programming languages and symbolic mathematics systems
- educational simulations and video games
- email, voice mail, and desktop video conferencing systems; and
- human genome data bases and digital cadavers.

We shall return to many of these in the remainder of this talk.

The most exciting of the new knowledge media is the World Wide Web. Let me quickly explain why, primarily for those who have just returned from 3-year sabbaticals on Fiji, although I understand that Fiji now has at least 3 Web servers.

The Web is a global hypermedia system. "Hyper" here means that it is a collection of electronic documents that are linked together, each containing embedded references to other documents. "Media" means that the documents include not only text but also graphics, sound, animation, and video. "Global" means that it exists in distributed form on computers located throughout the world, and it can be accessed from computers located throughout the world.

The Web now includes on the order of 100,000,000 pages located on the order of over 100,000 Web servers, that is, computers that store and transmit Web pages upon demand. These numbers were, as of 8 months ago, doubling every 123 days, that is, increasing at a rate of 800% per year.[18] This latter number is dropping year by year, and is likely soon to reach **only** 100% per year, that is, doubling every year, which has been the approximate rate of Internet growth since it was founded At least in North America, most major corporations, organizations, newspapers, and films now have Web presences--the ubiquitous *http://www.mumble.com.*

The Web is a knowledge medium, using modern computer and communications technology to enhance our creativity, our learning, and our knowledge building.

These new knowledge media are of great interest for four reasons:

- They incorporate both data and process.
- They are distributed in time and space, making them ideal for collaborators.
- They encompass task spaces and interpersonal spaces, which I shall define soon.
- They are extensible, meaning that their behaviour can be shaped by their users.

Let's look at each reason in turn.

Knowledge media, being computational artifacts, incorporate both data and process. In other words, unlike a traditional encyclopedia or reference work, which contain only facts, these new media can compute new facts, can configure and present information in unique ways based in part on rules built in to the medium and in part in response to actions and requests from their users.

Good examples are found in the domain of educational simulations such as SimCity and provocative multimedia titles such as Myst. Another is the work of Mitchel Resnick of the MIT Media Lab, who will speak here on March 20.[19] His Star-Logo language allows young students to build highly parallel simulations of complex systems such as found in biology, ecology, and transportation. [Shown here are four images from a forest fire simulation in Star-Logo.] Star-Logo is a knowledge medium, for it enables students to express their understanding of a phenomena such as forest fires as working computer simulation. Resnick's Lego-Logo and Programmable Brick systems also allow students to express knowledge as computer programs in order to build simple computer-controlled robots and performance art systems, such as the robots shown here.[20]

Knowledge media may be distributed in both time and in space. For example, electronic mail and voice mail systems allow us to send messages to people whether or not they can receive the messages at the moment, and, to an increasing extent, wherever in the world they are located.

The sociologists Lee Sproull and Sara Kiesler, among others, have studied and documented many impacts of electronic mail.[21] They point out that we should distinguish between the intended first order effects, such as faster communication, accessibility to a message anywhere in the world, or the ability to forward a message to a group with ease; and the unintended second order effects, such as decreasing the apparent distance between the CEO and workers in a company, decreasing the trappings of status that have been reflected in traditional forms of written correspondence, and receiving junk email.

Another example, which Irene Greif will discuss in the third lecture of this series, is Lotus Notes, software that allows companies to create corporate-wide organizational memories that include knowledge contributed by all members of the corporation.[22] Boeing is a company that has embraced collaborative technologies; Steve Poltrock will tell us why and how in his lecture on March 6th.

Knowledge media incorporate both task spaces and interpersonal spaces. *Task spaces* are environments, or frames, in which we carry out work, such as writing, drawing, and computing. Traditional task spaces include paper notebooks, drawing pads, and ledger sheets. *Interpersonal spaces* are the environments, or frames, in which we communicate with others about our work. Traditional interpersonal spaces include telephones, speeches, and conference rooms.

Hiroshi Ishii, a charming and brilliant researcher, recently visited U of T for a year and is now at the MIT Media Lab. Previously, while at NTT Labs in Japan, he produced a dramatic example of a knowledge medium incorporating both task space and interpersonal space. ClearBoard allows collaborators working on different computers who are also likely in different physical locations to share a common virtual drawing space (the task space), but also to see each other through the medium (the interpersonal space) as if they were on other sides of a semi-transparent glass panel.[23] Let's see how this works in the next video clip of ClearBoard.

Finally, knowledge media may be extensible. This means that the medium itself may be modified and enhanced to meet the perceptual, cognitive, and task requirements of its users. We can configure modern productivity tools, such as word processors, so that commonly used functions are close at hand. We can instruct our electronic calendars to remind us of important meetings and even more important birthdays. Corporations have adapted and extended the core technology of Lotus Notes to serve many purposes, such as sales lead tracking, customer support, and corporate intelligence.

Extending knowledge media is *designing new media*. This is arguably the deepest way in which the new knowledge media differ from the old. So let us now address the topic of "media design," after which we shall put it all together and discuss "knowledge media design."

5. Media Design

An artist, in the old world of atoms, can select a canvas, choose a set of pigments, mix colours, and then express an idea as a painting. When she finishes, she has a single work of art, located in one place and at one point of time.

In the new world of bits, she can also specify a digital canvas, choose or describe computationally a palette of digital pigments, and create a digital painting. Yet digital media allows her to create not only the *content* — what is being painted — but also *the medium* itself. For example, she can:

- design a medium so that it can store and replay the history of development of the painting
- ensure that we can transmit the painting now or later to viewing stations at many places in the world, and
- enable other artists to participate together in the creation of a family of paintings inspired by the same original work.

To repeat, because this may be my most important point today, the new technologies allow us to design *not only the content but also the media themselves*, McLuhan's "extensions of humanity." This is not historically unprecedented, as each new invention — painting and sculpture, the phone and the photocopier, the bicycle and the airplane — is a new medium. What **is** unprecedented is the speed and the fluidity with which this can be done. In terms of Negroponte meeting McLuhan (that would be worth an entire Woody Allen movie, and not just the short clip of McLuhan in the film *Manhattan*), bits are infinitely more malleable than atoms. This is a source of great power in providing sensori-motor, perceptual, and cognitive prostheses to ourselves and to the groups and organizations to which we belong.

This power manifests itself in different ways. I shall distinguish two broad classes.

First, we shall consider how we interact with these new digital media, in other words, with their input and output if they are viewed as computer-based systems. We'll look at examples drawing upon work at U of T in:

- 2-handed computer input
- desktop video conferencing
- adaptive technology

Secondly, we shall examine ways in which the media store and process information, documents, messages, and the like, in other words, with the processing and memory if the media are viewed as computer-based systems. Here we shall use one example from my research group, the real-time collaborative editing of documents, and return to other examples later in the talk.

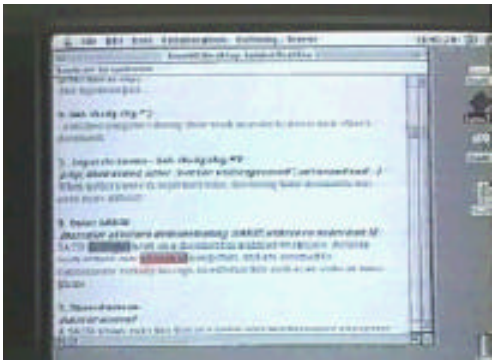
Adjunct Professor of Computer Science Bill Buxton, who is also Principal Scientist of Silicon Graphics, is fond of noting how ironic it is that one of his major contributions to computer science is the discovery that human beings have two hands. Why should our non-typing interactions with computer systems, our immersion in the new media of interactive computing, always consist of sequences of single mouse movements interspersed with mouse clicks? This next video sequence shows the work of Bill's recent Ph.D. graduate George Fitzmaurice, illustrating how interactive computer media may be designed for expressive two-handed computer input.[24]

Our second example of media design is also due to Bill. In the Ontario Telepresence project, he considered a similar problem in the domain of desktop video conferencing. If we are holding a meeting with several individuals, wouldn't we achieve a greater sense of presence if their images and their voices could be arrayed in space and not localized within a single video monitor?[25] This slide demonstrates the concept with a 3-headed videoconferencing display known as Hydra realized with the help of the Arnott Design Group.

U of T's Adaptive Technology Research Centre is one of our best-kept secrets. Under its able and energetic Director Jutta Treviranus, it is a service organization providing rehabilitative and assistive technology to students with handicaps.[26] It is also an R&D organization advancing the start-of-the-art in adaptive technologies, such as the alternative keyboards displayed in the slide. It applies and sometimes designs new kinds of computer media to deal with certain disabilities, such as its current experiment with using desktop video conferencing technology to allow a homebound student to participate in a class.

The last example comes from my own Collaborative Multimedia Research Group. It deals with the real-time collaborative editing of documents, in other words, how do we enable two individuals sitting at their own personal computers, which may be located in different parts of the world, to work concurrently on the same document.[27] Several slides of our prototype SASSE system will illustrate how this can be done.

1) We first show how what appears to be a WYSIWYG, What You See Is What You Get, text editor can be modified to allow several contributors, each portrayed by a unique colour, to work on a document at once. The scroll bars on the right show where each person is working.



2) One individual can show another the region of text to which she is referring. They are working together on a single paragraph through use of a WYSIWIS, or What You See Is What I See, view. They can link the views together so that they are guaranteed to scroll together.

3) In more loosely-coupled work, each individual can get a sense of where her collaborators are working and what they are doing by using split-screen displays, one dedicated to each individual; and,

4) SASSE also provides a "gestalt view" which gives an overview of the document and what others are doing.

All four examples, 2-handed computer input, 3-headed video conferencing output, adaptive technology, and synchronous collaborative writing, illustrate new media design, the creation of environments in which computer users live, new extensions of humans and their capabilities, new metaphors which translate experience into new forms. The last example, SASSE, differs somewhat from the first three in that it focuses more deeply on electronic documents that represent human knowledge, in this case, text designed to manifest the shared understanding and intentions of a group of co-authors. In creating SASSE, we were knowledge media designers. So, finally, what <u>is</u> knowledge media design?

6. Knowledge Media Design

Knowledge media design is the human-centred design of new media based on interactive computer and communications technology intended to enhance the learning, creativity, and knowledge building of communities of individuals.

There are 5 key aspects to this definition:

- designing and creating
- in a human-centred way
- new media which incorporate modern digital technology
- whose central purpose is to help communities of individuals
- think, communicate, learn, and create know-ledge.

Following Perkins, our designing involves "shaping objects to purposes." The objects may be documents such as computer-based hypertexts or entire digital libraries, artifacts such as virtual reality goggles and helmets, technologies such as those of three-dimensional computer graphics, and systems such as those for desktop video conferencing and collaborative writing.

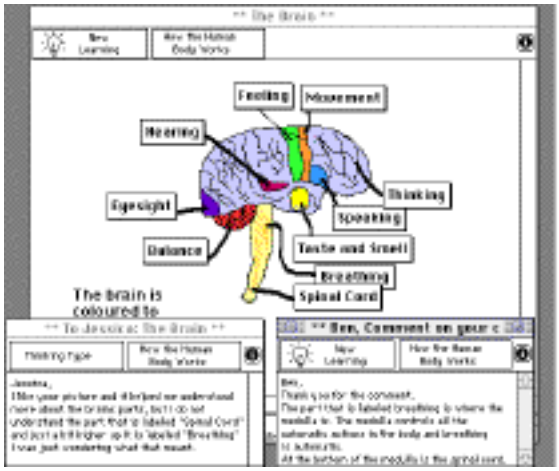
The designs leverage the power of computer and communications technology and result in new media, McLuhan's "extensions of humanity." Their purposes are to enrich our minds and extend our knowledge, individually, and as groups, organizations, and societies.

Finally, we do all this in a human-centered way, considering human values, involving potential users in the design process; seeking to employ what is known by cognitive and other behavioural sciences of how people think, work, and learn; and taking care not to fall so much in love with our technology that we lose sight of what it is for.

We shall look at five kinds of examples of knowledge media design, many of them represented by work at the University of Toronto:

- collaborative hypermedia for knowledge building and enhancing university education
- the design of new media, some based on the Internet and the World Wide Web, to support specialized distributed knowledge-building communities
- projects that use *multimedia* in knowledge media
- behavioural research on work process as it is changing with new technologies, and, finally,
- contributions of the professional design community.

Our first projects deal with collaborative knowledge-building and distributed intelligence. Marlene Scardamalia and Carl Bereiter of OISE/UT, in their pioneering CSILE project, have enabled children to work together in a classroom culture dedicated to collaborative knowledge-building.[28] Students contribute data, information, questions, hypotheses, and the like to a shared hypermedia database consisting of notes such as that shown in the slide.



They participate as co-investigators as the class builds knowledge about a topic under investigation, not as vessels to be poured full with data. The results are dramatic:

> *"Controlled studies show that students who use CSILE excel in a number of areas. They do better on standardized language and reading tests and are better able to comprehend difficult informative tests. They demonstrate advantages in the quality of the questions they ask, their portfolio commentaries and general depth of explanation, and their facility with graphics. They even demonstrate more mature beliefs about learning. The studies show, too, that students at the high and low ends of ability spectrums are equally engaged, and typical gender biases have not appeared."*[29]

We look forward to hearing about new directions for CSILE and Marlene's vision of a knowledge-building society in her lecture next week.

Two other interesting examples in this category are OISE/UT's Dan Keating and Andrew Cohen, who are studying the social and economic value of telelearning networks as the infrastructure for the development of a Learning Society, and are trying to use them in new settings such as community development; and Medicine's Lawrence Spero, who will speak on Feb. 27 about how the Internet and the Web can help us realize new models for education and training, such as contextual learning for health professionals.

Our second set of examples of knowledge media design deal with the use of the Internet and the Web to enable the formation of specialized distributed knowledge-building communities. Recently I took a whale watching tour off the coast of Mexico conducted by a tiny company called Ecotourism.

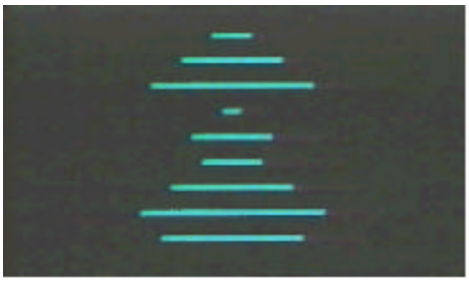
One member of the team photographs the flukes, or tails, of whales, then motors back to his computer to scan the markings into a computer database of all living humpback whales which can be used to study whale migration and monitor population health. There are fewer than 100 whale researchers in the world; they are an Internet-enabled community and plan to put the whale inventory on the Web.[30]

Two other examples from the scientific domain are the community of human genome researchers,[31] and the science learning network linking various science museums, teachers, and students.[32] Illustrations from the domain of the humanities are the Victorian Studies community,[33] the community of women writers,[34] and the community of individuals working on and interested in illuminated manuscripts.[35]

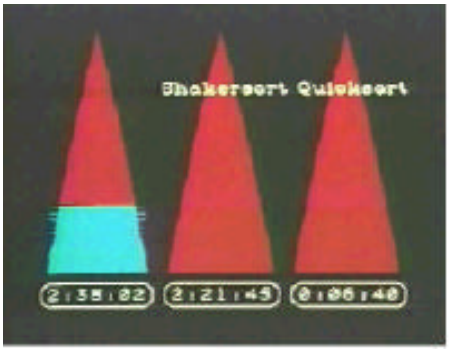
A third theme in knowledge media design is bringing multimedia into the media, in other words, using graphics, sound, animation, and video to enrich and enliven our learning and knowledge building experiences. Here we shall again see the importance of methods of representation.

The first example comes from computer science education. In 1981, I completed a computer-animated teaching film on computer methods, or algorithms, for sorting data, that is, for rearranging the elements so that they are in order. Hockey players may be sorted in alphabetic order, or according to lifetime goals scored.

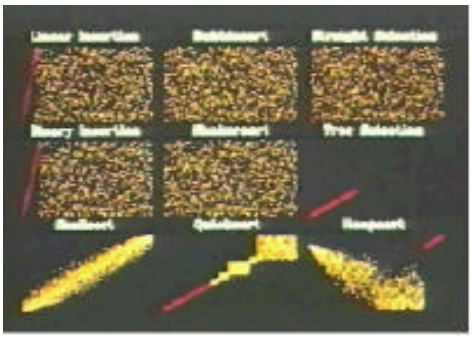
Sorting Out Sorting brought the algorithms to life by showing the data rearranging itself as the computer carried out the method.[36] The design of representations was critical because I first wanted to show the algorithms working on 10 items, in a step by step explanation; then on 250 items, comparing 3 different methods; and finally on 2500 items, comparing 9 different methods. In the first case I used rectangles, whose width represented each datum. We'll just give a quick sense of the animation, with a 12-times speeded up version: (Video clips from *Sorting out Sorting* shown.)



Next, I employed straight lines, with the length representing each datum, again shown here in a high-speed version:



Finally, I used dots, with the vertical position representing the datum. Here, unsorted data appears as a yellow cloud, sorted data as a red diagonal line.



Although the first two animations are best viewed at normal speed in the context of the entire 30-minute movie, the point is that the animated film engages the student and aids in comprehension of the material.

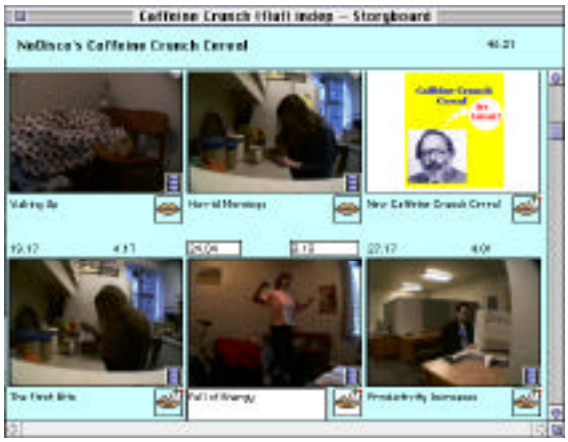
A problem that must ultimately be solved if video is to be as ubiquitous as text in the knowledge media of the future is how to index and annotate sequences so that they are easy to retrieve and reuse them in other contexts. The stunning proposed solution in the Ph.D. work of the Media Lab's Marc Davis is illustrated in the next video clip.[37] The work is called Media Streams. (A video clip from Media Streams was shown.)

The final example of multimedia is my lab's computer-based movie authoring and design, or MAD system.[38] Traditional filmmaking technology forces the author to deal separately with scripts, storyboards, still art, audio, and video. Our vision was a system that allows incorporation of these disparate elements in an integrated multimedia

database in a way that enables one to work top-down, in terms of the high-level structure of the movie, and bottom-up, in terms of the details, much as I was able to do with this talk. Another goal was that a film author be allowed to request a real-time playback of an approximation to the final film at any point in the creative process. A third goal was that she be able to interact with the film through a variety of representations — there's that concept again — including traditional film artifacts such as scripts and storyboards. And, finally, we wanted to be able to transmit the resulting digital movies over the Internet to viewers and collaborators anywhere in the world.

Here is a slide of a MAD script view in which we can see the top-level structure of the movie, consisting of four acts.

Next we see an expanded script view that shows the scenes in the first act. Then comes a MAD storyboard view. Any of these views may be input and manipulated by the filmmaker.



Our last still frame is a shot of a playback view in which we can also see the dialogue or narration and the director's notes. Finally, let's view the movie, an advertising film entitled *Caffeine Crunch* that represents a few hours of work by graduate student Naomi Friedlander. (A video clip showing the "almost final" MAD movie was shown.)

Now on the fourth theme. Multimedia is essential for knowledge media design, but human-centred design cannot be based on technology alone. We need *both* significant technology innovation *and* deep insights into human beings. This was stressed in the mid 80s in the pioneering work of anthropologist Lucy Suchman of Xerox PARC, showing the importance of understanding real work in real work contexts as opposed to developing abstract cognitive models of ideal work process.[39] Dr. Suchman will share her insights with us in her April 10th talk.

A local example is the research on telework carried out by Janet Salaff and Barry Wellman of the Department of Sociology.[40] Given that new knowledge media allow one to work from almost anywhere — let's call this *telework* — it is important to understand telework's impacts on, for example, work process, work product, job satisfaction, and home life. Their most interesting finding is the distinction between what they term *cool jobs*, with structured work and rigid procedures, which seem to lend themselves to telework very well; and *hot jobs*, where employees require more supervision, coaching, and assistance in problem solving. They found that hot jobs are less suitable for telework.

The final two examples of knowledge media design come from the work of professional designers, whose job it is to imagine what might be possible, and to sketch, both literally and figuratively, what it might look like and how it might behave. The eminent graphic designer Aaron Marcus will share with us his work on visualization of knowledge media in a lecture on April 3rd.[41] These images show work by his firm on prototypes of the user interface for Motorola's intelligent vehicle/highway system navigation assistance device.

U of T has been enriched by the beautiful urban design applications of graphical knowledge media (3D computer graphics and geographic information systems) carried out by John Danahy, Rob Wright, and Rodney Hoinkes of the Centre for Landscape Research.[42] [Shown here is one image from a historical reconstruction of old Montreal.] The work is carried out with technical dexterity and visual sensitivity. It is rooted in real data, lots of it, so what we are seeing is as historically accurate as possible. It brings complex spatial and temporal data to life, turning data into information, and hopefully also into knowledge and even wisdom. The work is useful for design and planning, museums, and education.

Clearly, knowledge media design is a new field of incredible breadth and scope. But let's be careful. Is there anything that is **not** included? We use this question as to begin our concluding remarks about knowledge media design at U of T.

7. Knowledge Media Design at U of T

Knowledge media should not be equated with digital media. The video game Mortal Kombat is not a knowledge medium; it is not responsive to human values. Software that computes payrolls is not a knowledge medium; even if

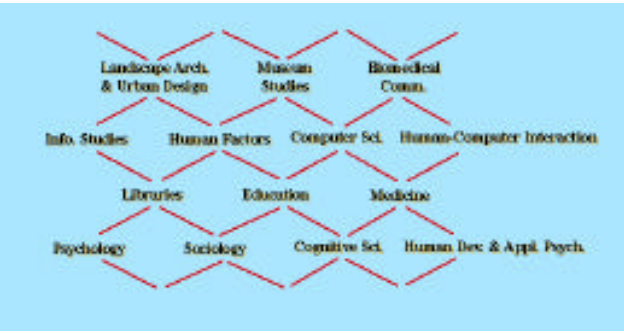
does enhance knowledge, it does not do so for a community, unless a bug broadcasts all salaries throughout the company. Knowledge engineering of expert systems as practiced by the artificial intelligence (AI) community does not usually result in knowledge media, if its central purpose is to automate human expertise and not to enhance it.

One of the most literate and thoughtful of the artificial intelligentsia, Mark Stefik, was probably the first to use the term "knowledge media," although the origins of the concept appear in writings of Bush, Licklider, Engelbart, Nelson, and Kay.[43] In a 1986 paper entitled *The Next Knowledge Medium*. Stefik defined it as "an information network with semi-automated services for the generation, distribution, and consumption of knowledge," and proposed this is a "larger and complementary goal" to the "most widely understood goal of artificial intelligence...to understand and build autonomous, intelligent, thinking machines."[44] (Although we define knowledge media in a slightly different way, we share Stefik's goal for the AI community.)

So this is our mandate, new media for human learning, community growth, and knowledge building. This new discipline incorporates aspects of:

- computer science, which teaches us how to construct digital media
- human-computer interaction and human factors, which study the user-centred design of technology
- psychology and cognitive science, for knowledge media design must be rooted in an understanding of learning and creativity
- the social sciences, which teach us about groups and organizations, and
- the design disciplines, because knowledge media must be well structured, employ effective representations, and be communicative and attractive.

The slide shows departments contributing significantly to KMDI at U of T.



Why do we need a new discipline? The answer is simple. Existing disciplines, under the continued onslaught of budget slashing, and through increasing specialization and competitive publishing pressures on young academics, are getting *narrower*, not broader. Many of the individuals whose research has been cited, and others omitted due to lack of time, feel themselves at the fringes of their current disciplines. Knowledge media design represents a new center, a common ground for a new intellectual community with a mandate that is increasingly relevant as we move into the new millenium.

The mission of this community, the Knowledge Media Design Institute, is research and graduate education in the knowledge media arts and sciences. We have begun vigorously, sponsoring an informal seminar and discussion series, last spring's Internet 2000 Conference, this series, a graduate course which is using the series as a resource, and several large grant proposals. We are not alone in this effort.... (A discussion of other centers such as the MIT media lab.)

We intend both to *develop* and *think about the implications of* new knowledge media, and to do research on social and ethical issues. Andrew Clement from Information Studies will deal with policy issues in the final lecture of this series. Several issues particularly concern me, including who has power over whom, how work is changing, and how we achieve a balance between intellectual property protection and desirable usage. I will speak here only about one issue — literacy and accessibility. The data on the next 3 slides dramatically illustrate the gaps between rich and poor, between young and old, both in terms of who owns personal computers and who is able to use them.

% of households with PCs based on income (1994)

Lowest 20%	9%
Second lowest 20%	15%
Middle 20%	22%
Second highest 20%	33%
Highest 20%	60%

% able to use PCs based on household income (1994)

Under $20,000	28%
$20,000 - $29,999	38%
$30,000 - $39,999	52%
$40,000 - $49,999	60%
$50,000 - $59,999	72%
$60,000 - $99,999	80%
$100,000 and over	86%

% able to use PCs based on age group (1994)

15 - 24	81%
25 - 34	68%
35 - 44	66%
45 - 54	55%
55 - 64	36%
65 and over	10%

Note that this data says nothing about one's ability to use computers to learn or to participate in a knowledge society, and it deals only with Canada, and says nothing about gaps in other parts of the world. KMDI must work on the problem on increasing literacy and ensuring that the benefits of knowledge media are available to wider groups of people.

Now, while you're formulating your questions, which we'd like you to write down on the cards that have been

provided, I'd like to finish with some special thank-yous... to members of the KMDI Steering Committee (Carl Bereiter, Mark Chignell, Andrew Clement, Eugene Fiume, Dan Keating, Gale Moore, Janet Salaff, Ian Spence, Lawrence Spero, and Rob Wright), to University of Toronto administrators (Adel Sedra, Heather Munroe-Blum, Jon Cohen, Wayne Enright, Michael Fullan, Lynne Howarth), and to John Chattoe, President of ITRC, who have provided financial and moral support, and also, in the case of ITRC, more support specifically for this series. I am also very grateful to Lil Blume and Philip Stern, and especially to Ann-Barbara Graff, Ali Mazalek, and Marcia Chen for help organizing the series and preparing this presentation.

Science journalist Harry Gefen will take written questions and organize and ask them. Later we will have time for longer comments from the floor. And during this we will put up on the screen a slide about upcoming lectures in this series.

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[4]Jacques Bertin, *Semiology of Graphics: Diagrams, Networks, Maps*. Trans. William Berg. (Madison: UWisconsin Press, 1983).

[5]Edward Tufte, *A Visual Display of Quantitative Information* (Cheshire, Conn: Graphics Press, 1983).

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[7]Donald Schon, *Educating the Reflective Practitioner* (San Francisco: Jossey-Bass, 1987) xi.

[8]Marshall McLuhan, *Understanding Media* (New York: McGraw-Hill, 1964) 23, 65.

[9]McLuhan, *The Medium is the Massage* (New York: Bantam, 1967) 26.

[10]Nicholas Negroponte, *Being Digital* (New York: Knopf, 1995) 61.

[11]Perkins, 1.

[12]Henry Petroski, *To Engineer is Human* (1985); *The Pencil: The History of Design and Circumstance* (1990); *The Evolution of Things* (1992); *Design Paradigms* (1994); *Invention by Design* (1996).

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[16]John D. Gould, "How to Design Usable Systems" and Clayton Lewis and J. Rieman, "Getting to Know Users and Their Tasks" in *Readings in Human-Computer Interaction*, ed. R. Baecker, J. Grudin, W. Buxton and S. Greeberg (San Francisco: Morgan Kaufman, 1995).

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[18]<http://www.useit.com/alertbox/9509.html>

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[20]Mitchel Resnick examples.

[21]Lee Sproull and Sara Kiesler, *Connections: new ways of working in the networked organization* (Cambridge, Mass: MIT Press, 1991).

[22]Lotus Research papers are available on line at <www.lotus.com/research>.

[23]NTT, "Seamless Media Design," SIGGRAPH Video Review, CSCW '94 Technical Video Program, Issue 106, Item 10, ACM, New York, 1994; Ishii, H., Arita, K., and Kobayashi, M., "Toward Seamless Collaboration Media: From TeamWorkStation to ClearBoard," SIGGRAPH Video Review, CSCW '92 Technical Video Program, Issue 87, Item 6, ACM, New York, 1992. URL <http://ishii.www.media.mit.edu/people/ishii/publications.html>

[24]George Fitzmaurice, *Graspable User Interfaces* (PhD thesis, University of Toronto, 1996).

[25]Hydra URL: <http://www.dgp.utoronto.ca/tp/techdocs/Hydra.html>

[26]ATRC URL: <http://www.utoronto.ca/atrc/>.

[27]SASSE Posner, I.R., Mitchell, A., and Baecker, R.M. "Learning to Write Together Using Groupware" in Rada, R. (Ed.), *Computer Supported Cooperative Writing* (1996); Baecker, R.M., Glass, G., Mitchell, A., and Posner, I.R. " SASSE: the Collaborative Editor." 8 minute refereed video tape presented at the 1994 ACM Conference on Human Factors in Computing Systems, May 1994; also published in the *SIGGRAPH Video Review*, 1994.

[28]Marlene Scardamalia and Carl Bereiter, "Computer-supported intentional learning environments" in *Journal of Educational Computing Research*, v. 5, n. 1 (1989) 51-68; *Surpassing ourselves : an inquiry into the nature and implications of expertise* (Chicago : Open Court, 1993).

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[30]Eco-tourism

[31]Human genome research

[32]Science and learning.

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[34]URL <http://www.cs.cmu.edu/People/mmbt/women/writers.html>

[35]URL <http://colophon.com/gallery/minsky/illum.htm>

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[38]Baecker, R.M., Rosenthal, A., Friedlander, N., Smith, E., and Cohen, A. "A Multimedia System for Authoring Motion Pictures." *ACM Multimedia '96*,; Rosenthal, A.J. and Baecker, R.M. "Multimedia for Authoring Motion Pictures." *Proceedings of Graphics Interface `94*, pp. 133-140.

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