

There is a collection of issues, that in principle, should be on the table when one thinks about the design of multimedia for educational purposes. Perhaps the most economical way of presenting these issues is in the form of a set of questions, the first of which I pose in the title of this essay -

What Happened...

...to the Voice of the Author?

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What do I mean by this question? Consider, for example, your favorite five pieces of educational software. How readily can you identify the author of each of these pieces? Why is this important? ...because there are educational consequences and entailments to the answer to the question. In whatever medium they create, authors impart to their productions both a point of view and an argument. What they choose to include and exclude constitutes their *schema* for a way to approach a subject and to think about it.

One can imagine a range of views on this question of authorship. Allow me to cite two rather diametrically opposed views. The first comes from David Gelernter at Yale, a rather thoughtful man who has paid a great deal of attention to some of the more philosophical issues raised by the technological revolution we are in the midst of:

HYPertext YES, LITERATURE NO

*"...in a hypertext system, the computer allows you to assemble fragments of text and read them off the screen in any sequence that appeals to you, without guidance from the author, as if you were a bird gaily weaving your nest out of random bits of trash. But if you sacrifice literary architecture, the logical unfolding of an argument or a plot, you sacrifice literature. ...hypertext literature isn't merely bad, it's silly. Rotten education is a grave evil; hypertext-as-literature is a bit of nonsense that will blow away as soon as the next good fad kicks up."*¹

This is clearly a strongly held position and a cogent one although it is relatively easy to find fault with it. I think the flaw in Gelernter's argument is that it doesn't have to be that way. The fact that the medium permits this sort of abuse, is not a guarantee that

¹*National Review*, David Gelernter, 6/12/95 p.65

in any given production it will be abused in this way. Nonetheless, the frequency with which this sort of abuse does in fact occur suggests that it is a perspective worth keeping in mind.



Here is a different point of view. It is that of Brenda Laurel, a well-known author of books on software design.

MULTIMEDIA IS OFF THE BEATEN PATH

"We are working with a medium where one can no longer have an authorial voice. Many of us may not know that yet, but it turns out that we are no longer in the business of authoring narrative, or even of predisposing people to construct a particular narrative, or to find the right path through anything."

²

This, too, is a strongly held position, that one should keep in mind when one starts to think about structuring a multimedia piece for education. Does one really want to build something that doesn't, as Laurel says, help anyone "...find the right path through anything"?

There is an ideological position with respect to education that says, —Equip a child with the right set of intellectual tools, and then get out of the way because they'll reinvent the calculus and they'll rewrite the Beethoven sonatas. Having discovered the glories of intellectual exploration, many educators rush to adopt the position that all students should acquire all their knowledge by recapitulating the momentous insights of past creators.

I believe this is a foolish position. As best we can tell, there was *one* Newton, but there weren't a lot of folk who invented the calculus. There was *one* Beethoven and certainly there was only *one* Mozart. It is disingenuous to claim that the right set of tools is, in and of itself, sufficient to allow everyone to re-create the extraordinary depth and breadth of our culture.

²*Careers in Multimedia*, Brenda Laurel, Vivid/Ziff-Davis

On the assumption that we, both individually and collectively as a society, are not willing to give up the notion of a message, an authorial voice, and an intellectual agenda for a multimedia piece, *and* on the assumption that we want to take advantage of the hitherto unavailable opportunities that now present themselves with the availability of multimedia environments, what do we do? How can we take advantage of what many of us believe to be a truly unique set of opportunities to enhance our students' learning and understanding?

Is there still a place for a message ...

...now that we have a **multi**medium?

Many years ago Marshall McLuhan³ warned us that we were in danger of becoming more attentive to the form of the message and the medium of its transmission and less attentive to its content. Since it the premise of this discussion that we are unwilling to stop attending to message content and the voice of the author who formulates that message, it behooves us to turn our attention to the changing nature of messages that are to be transmitted in newly emerging media. Specifically, we are interested in the educational messages teachers and students exchange and the ways that these messages could and should (or should not) change.

What are our goals for the messages we prepare for our students? Whatever the medium we use, we want our students to acquire both *knowledge* and *understanding* and perhaps even *wisdom*. It is important to stress that these words that are not interchangeable. They mean quite different things. You might know the density of mercury or the year Chicago was settled. These are bits of knowledge. Understanding is quite a different story. Understanding why mercury is a liquid at standard temperature and pressure or why Chicago was settled where and when it was involves a different kind of intellectual activity. The beginning of wisdom may lie in being able to think cogently about how much mercury a civilized society can permit in its water supply or how the structure of urban life could and should change to reflect the changing nature of work, transport, health care, families and communities. As Alfred North Whitehead in *The Aims of Education* said “knowledge shrinks as wisdom grow; for details are swallowed up in principles. ...the habit of active utilization of well-understood principles is the final possession of wisdom”⁴.

³*Understanding Media*, H. Marshall McLuhan, 1964

⁴*The Aims of Education*, A.N. Whitehead, London, MacMillan, 1929

I believe that the development of *wisdom* is something that is fostered in close human interaction with caring others. I would be more than content if we can come to understand how to use the new media simply to broaden our students' *knowledge* and deepen their *understanding*.

There is no question that one of the extraordinary features of new technologies is that access to *knowledge* is dramatically expanded. We are now able to have a thin disk that fits in a shirt pocket that contains a total of 600 Megabytes - about 200,000 pages of dense print. Soon the disk in our pocket will hold five times as much information. This means that information resources of a great university library or the Library of Congress are now available well beyond particular geographical sites.

As if this dramatic expansion of information resources were not sufficient, the growing access of students and teachers to the the Internet and the World Wide Web is coming to mean that for a growing number of people access to raw information is less and less constrained.

This wealth of readily accessible information has prompted an enthusiastic proclaiming, by both educators and politicians, that a cure for the problems of our educational system is near at hand. Indeed, to the extent that education is about the acquisition of *knowledge*, this view probably has a good deal of merit. One is tempted by this interpretation because *knowledge*, as opposed to *understanding*, is what is normally assessed in judging achievement of both individuals and schools. This would seem to suggest that we are willing to settle for educational systems that broaden our students knowledge, but do little to deepen their understanding.

The rhetoric of education, however, continues to talk about the importance of both knowledge *and* understanding. Unfortunately, there is now (& always was) a danger of confounding knowledge with understanding. How then shall we distinguish between the two?

I believe that understanding inheres in part in the ability to link pieces of knowledge in appropriate ways. Further, I believe that knowing how others have done this is often helpful. Moreover, it is worth trying to characterize two levels of understanding beyond simple understanding. These are **deep** understanding and **creative** understanding.

I believe that **deep** understanding inheres in part in the ability to link pieces of knowledge in multiple alternative ways - doing so often calls for the use of a variety of representations that may call upon people to use quite different cognitive modalities to read and interpret the links among the pieces of knowledge. I am thinking here of the ability to use graphical, symbolic and verbal representations for the representation of relationships among pieces of information.

I believe that **creative** understanding inheres in part in the ability to link pieces of knowledge in ways that others have not done before. It should be stressed that creative understanding does not necessarily imply deep understanding or *vice versa*.

It is clear that the new technologies have much to contribute to the education enterprise so long as we focus on the *knowledge* dimension. But this is not sufficient given that we are committed to enhancing both our students' *knowledge* and their *understanding*.

Do the new technologies have a unique contribution to make when we focus our attention on the *understanding* dimension of the education enterprise? I believe they do - but in ways that are either uncommon, or fraught with intellectual danger, or both.

We are thus led to the question:

Are all subjects well suited to multimedia ?

To answer this question, we must ask about any given subject “what is the balance between knowledge and understanding in the subject?” I believe this question to be of central importance because the way in which the new technologies can broaden knowledge are really quite different than the ways in which they can deepen understanding.

To be sure, all subjects entail both knowledge and understanding. The consensus of opinion about the balance will vary from subject to subject. Moreover, for any given subject, different people may well have sharply different views about this balance. For some people history is primarily about the facts of the past and mathematics is primarily about intricate chains of inference leading from postulates through long inferential chains to proofs of theorems. For others, history is about the tapestry of historical forces and personalities that shape one another and mathematics is a compendium of facts and formulas.

Let us consider separately the ways in which the new technologies might best support the knowledge and understanding dimensions of education.

Expanding knowledge and the new technologies

In my view supporting learners as they broaden their knowledge is best done with richly indexed compendia. Unfortunately, this simply stated maxim implies the solving of problems we are only barely beginning to appreciate. For example, how does one assemble an archive so as to promote the development of intellectual taste and judgement in the users of the archive.

Once an archive is assembled, how does one approach the problem of indexing the archive so that it can be searched effectively and provocatively?

One can think about organizing an archive with indicial markers that are absolutely arbitrary. We have done this for centuries - the most interesting example of such an archive is a dictionary. Because the definitions in a dictionary are arranged in alphabetical order, a definition may have little semantic relationship to the preceding or to the following definition. The dictionary is organized in a way that has nothing to do with the conceptual content. Let us not sneer at this sort of artifactual organization of information. The alphabet has served us in very good stead. It is an extraordinarily clever invention, and it has its uses. On the other hand, there is the nagging feeling that in many instances we can do better by organizing information conceptually.

One may want to organize the body of information on the basis of some artifactual property. For example, one may be interested in doing something with Spanish or French grammar and may decide to organize the archive according to verb endings.

For certain sorts of archival material, spatial indicial markers are appropriate. Consider, for example, the case of Geographical Information Systems (GIS). In this kind of application a spatially-based conceptual organization is both clear and useful. I have this wonderful CD ROM that contains maps, on all scales from the continental to the individual street, of the entire United States. It is absolutely marvelous. I can readily find the maps, on several different scales, that I might need in order to reach any place in the country. The fundamental organizing principle is space. The internal relationships among individual pieces of information in the archive are imposed by our understanding of space.

For others sorts of archival material, temporal indicial markers may constitute the most useful indicators of the contents of the knowledge base. There are all kinds of archives that are maintained temporally. These need not necessarily be unidimensional. A combination of time's arrow and the concepts of simultaneity, precedence and succession allow genealogy trees, for example, to be rich archival devices.

However, it is difficult to imagine the obvious indexing strategies of spatial or temporal indicial markers being sufficient for all possible bodies of knowledge. Going beyond these strategies requires artistry and a clear view of how one wants the *corpus* of knowledge to be used. This is of particular importance when one considers the problem of linking disparate pieces of information to one another.

Suppose, for example, one is interested in doing something with multimedia in elementary school mathematics. Wouldn't it be interesting to have a large archive of interesting and engaging problems and projects for kids to work with. Consider the indexing problem. One can index the archive by whether or not they use rulers or small spheres. Indeed, one might in fact have that as one field in a record, but it is difficult to imagine anyone thinking that this kind of information should be the central organizing spine of such an archive.

One needs a better way to structure individual records. How does one think about the similarity or dissimilarity of elementary school mathematics tasks? For example, here are two tasks: a) suppose I have an octagonal dinner plate that fits in a case that's just big enough to hold an octagonal dinner plate. In how many ways can I put the plate away in the case? and, b) How many whole numbers between one and one million read the same forward and backward? Are those two problems related? If they are not directly related, could there be a string of tasks that at one end relate to the first task and at the other end to the second? This is the problem of conceptual indexing and thus the problem we find ourselves confronted with as soon as we depart from either sheer artifact or the obvious organizing principles of space and time.

Deepening understanding and the new technologies

The special role of the new technologies in deepening understanding is really quite different than their role in expanding knowledge. Here it is the ability to fashion software environments that reflect the consequences of users' actions back to them that constitutes the special opportunity for education. Elsewhere I have called such environments “intellectual mirrors”⁵. Such environments provide non-judgmental settings in which users can probe their understanding by making and exploring conjectures about the system they are studying. Typically we think of simulations and “supposers” as the software genres that permit this sort of exploration.

Intellectual mirror environments can be of enormous help in deepening both students and teachers understanding of complexity. Two *caveats* must, however, be emphasized so that we avoid misplaced and inappropriate enthusiasms for such software environments. First, all simulations are articulations of the author's model of the way the system in question behaves. As with all models, some aspects of the system being modeled will not be incorporated in the model. In a skillfully crafted model, this discrepancy may not interfere seriously with the utility of the simulation. Nonetheless, there are situations in which the predictions of the simulation will differ from the behavior of the system that it purports to model. Under such circumstances, we must be scrupulous in stressing to our students that in the event of a conflict between nature and a simulation of nature we must always resolve the conflict in nature's favor.

There is a second *caveat* needed for dealing with intellectual mirror environments. Because it is inevitable that these environments will fail when applied inappropriately, I believe that it is morally incumbent on us to make the internal workings of such software environments available to the users. This means giving the user the ability to examine how the simulation chooses to behave as it does at any given juncture. Unfortunately, most designers of simulations do not share my belief about the need to do this.

⁵*Intellectual Mirrors: A Step in the Direction of Making Schools Knowledge-Making Places*, in Harvard Educational Review, Vol. 59, No. 1, February 1989.

With these thoughts as background let's return to the question, "Are all subjects well-suited to multi-media?" When we consider designing a piece of software in any given subject area, we must decide for ourselves what balance of knowledge and understanding we would like to strike in the design of the piece.

Thinking through this balance of knowledge and understanding goes a long way toward clarifying one's pedagogic stance toward the subject of the prospective software. Having done so, one can then turn to the central question entailed by the title of this essay, i.e. what is it that that the author wishes to say.

This is not always easy to do. Indeed, for most pieces of educational software it would seem that this question is not adequately considered. I am reminded once again of the importance of a lecture that I heard the historian Barbara Tuchman give many years ago. This lecture was entitled "How I Write My Books." After she was introduced Ms. Tuchman got up and opened with a remark that I will never forget. She said, "First you have to have an idea."

All of this points to the following question, i.e.

How do navigational tools

[constrain / promote]

the acquisition of *knowledge* and *understanding* ?

In a recent issue of *Technology Review*, Langdon Winner writes⁶

"...hypertext structure slices through long-standing conceptual hierarchies like a hot knife through butter. Monuments of knowledge, complicated distinctions that took centuries to erect, are reduced to a set of endlessly malleable hot links. Over the long term, arranging information in this way may help reveal unexpected connections between diverse realms of knowledge and stimulate the imagination. But for now, there will continue to be a great deal of confusion and futile effort; reports frequently arise of wasted afternoons spent plowing through the Web trying to find that one morsel of useful information amidst the vast reservoirs of gossip, rumor, and political propaganda. Hope springs eternal; with all this horse manure, there's just got to be a pony in there somewhere."

⁶ *Technology Review*, Langdon Winner, Nov/Dec 95 p66.

Although Winner is writing about the World Wide Web, his remarks are appropriate to any multimedia production, be they online or stand-alone. The challenge he puts to us is one of designing environments for the broadening of knowledge and the deepening of understanding that allow us to capitalize on the unusual and unexpected while not foregoing that which took "...centuries to erect". The problem of structuring a body of information so that when it is embedded in a multimedia environment it is flexible and responsive to the idiosyncratic curiosities of its users *while at the same time* preserving a clear authorial voice is a serious problem. So too is the problem of providing a set of tools for exploring the logical consequences of one's conjectures in a way that promotes the rediscovery of the past of a discipline and the invention of its future. Let us consider each of these design problems in turn.

Turning to the first of these problems, I would like to suggest a kind of topology for the internal interconnectedness of multimedia environments whose central purpose is the broadening of knowledge.

A PROPOSED TOPOLOGY FOR THE DESIGN OF MULTIMEDIA EDUCATIONAL MATERIALS



Let us call the light circle a node of order zero, a circle with a heavier line weight a node of order 1, etc. The proposed organization has users beginning with a node of order zero. The environment permits them to move from there to any of a variety of other nodes of order zero. This collection of nodes to which they may move can be thought of collectively as a node of order 1 as indicated in the diagram. From the node of order one, their options open up to a collection of order 1 nodes, which may be collectively thought of as a node of order 2, etc. As they progress through the material, the option close down and converge to a node of order zero at which all users eventually arrive. Then the process repeats.

What I am describing is tree of options that starts at a well defined place and opens up into a rich array of possibilities, but then closes back down. Then opens up again, then closes back down. Thus everyone who traverses this structure will have had to traverse all the nodes of order zero. Between consecutive nodes of order zero, the sequence of experiences any given user may have is likely to differ greatly from those had by any other user.

This central spine of nodes of order zero, is a mechanism that can preserve the voice of the author. Since all users must traverse the set nodes of order zero, this sequence of nodes provides the author to convey the idiosyncrasy of his or her perspective on the subject to all the users of the environment. In this sequence of nodes can lie the non negotiable core of the authors message. On the other hand, the diverging and converging trees linking the nodes of order zero, allow for a multiplicity of trajectories through the material as well as for idiosyncratic individual exploration.

This is an attempt to think about how one can capitalize on the openness and the flexibility of the medium and medium's ability to link things while preserving the fact that this is put together by a human being who has something to say. It is summarized in the following table.

<p>The central spine of nodes of order zero</p> <ul style="list-style-type: none">• preserves the voice of the author• presents the non-negotiable core of the authors message <p>The diverging/converging trees linking nodes of order zero allow</p> <ul style="list-style-type: none">• a multiplicity of trajectories through the material• idiosyncratic individual exploration
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I want to turn now to another issue raised by the medium and which I think of as the following

the **power** & the **peril** of the **particular...**

or... How can we balance

A
picture
is worth one thousand
words

with

A
word
is worth one thousand
pictures

?

How can we reconcile the specificity of multimedia images and sounds with the generality of the abstractions we hope to have students master. This is a quite general question that is raised by the powerful effects of the imagery so prevalent in multimedia environments.

Let's take some examples from a variety of domains to illustrate the issue. A picture of a cat depicts a particular cat with a particular coloring, a particular length of tail, particular shape of leg, and particular fur length. It might be a saber tooth tiger or an alley cat. It is a particular animal. On the other hand when I say the word cat, every reader will have a mental image that may or may not correspond to that of any other reader. Nonetheless, we can communicate verbally by using the bit of language that is written as **C A T**. There is an abstract notion of cat, which is carried much more readily by the language than by the image.

This presents us with an interesting conundrum as we consider the design of multimedia environments for education. There is no question that multimedia deals in the specificity of images and sounds. Indeed, the seductiveness and attractiveness of the medium lies in its ability to do just that. But the images and sounds are particular, and necessarily so. Multimedia images and sounds are not abstractions and, in the end, we need abstraction.

Consider some specific examples. Geometry is one. The reason it is an interesting example is that the human mind needs images to think about spatial things. But the images are of necessity specific. If I draw a triangle with a particular set of angles, there is only one triangle with that particular set of angles, size aside. One needs images. but the image is specific, and the intellectual domain deals with abstract classes such as triangles. The theorem that the sum of the angles in a triangle is 180° does not apply simply to the the triangle drawn to accompany the proof but rather to the uncountable number of triangles that one can imagine.

Zoology offers another case of the tension between the specific and the abstract. There are many different kinds of animals all of which are said to be cats. What is a cat? Obviously there is the abstract notion of cat and there are many specific instances of cats. Both ideas are necessary - neither is sufficient.

History provides yet another interesting example. What is a revolution? If you study the French Revolution then what do you understand what went on in Russia in 1917, or in the late fifties in Cuba, or in England in the early nineteenth century, or around the world in our very own day. You have no alternative but to study the detail of the individual cases. But each is called a “revolution”. What makes it so? Once again we see the fugue between particular and general.

Perhaps the most interesting case of all is language itself. What is a verb? English is a particularly interesting domain in which to ask that question. The dictionary definition is “The part of speech that expresses existence, action, or occurrence.” English is very permissive in the sense that it allows us to take virtually any noun and turn it into a verb. Although some people may object to such usage, we are quite comfortable saying, “Karen chaired the meeting.” or “Paul hammered the nail.” It would also be completely understood if I were to say “I jacketed myself this morning.” Moreover, the statement is syntactically correct. But is jacket a verb? And thus the question remains - we know many specific instances of verbs, but how do we define the abstract concept *verb*?

The reason for fussing with this point is that I would like to make the argument that

the point of education is...

...abstraction and its many representations

A good part of our educational rhetoric speaks of the importance of “hands-on” education. It is unfortunately all too easy to lose sight of the fact that the purpose of “hands-on” is to get to “minds-on”. We really do need to get to abstraction for it is only with abstraction that we can move beyond the immediate. The reason that we study the great Russian novelists of the 19th century is not simply because they told good stories although they certainly did that. We study these authors because their stories are emblematic of the human condition. In each case there is much to be learned that goes well beyond the individual tale.

The purpose is education, in my view, is to get people to internalize the asking of the question - “What is this a case of?” This has always been a difficult task. In a way it becomes a more difficult one with the growth of multimedia educational materials because of the power of multimedia is to present the specific. The challenge is to capitalize on this power without allowing it to defeat us in our central goal of provoking people to ask “What is this a case of?”

The final caveat...

Finally, one more point⁷. We must now learn to be skeptical of images and sounds that purport to displace reality in space and time. We have tools that allow us to fashion images and sounds that are as faithful to the eye and the ear as we are able to discern. This ability requires us to weigh evidence in new ways and to think both more broadly and more deeply about what it means for something to be true or not true. We must make sure that the seductiveness of multimedia and its rich and abundant availability of images and sounds and the ability to manipulate them does not become a poison apple.

We must learn...
...where Truth Lies

⁷I am deeply indebted to my former student Robert Mohl for allowing me to read an unpublished work of his entitled “Learning where the Truth Lies” which sensitized me to this issue and helped me to understand better the seriousness of it.