

Educational Multimedia: Perspective In Evolution

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Abstract

The future of multimedia technology is guided by how its use evolves. In this paper we review that evolution with respect to one domain for the application of multimedia: education. Three perspectives are examined: standalone use, Internet access, and digital library. Close experiences with projects that exemplify these perspectives provide the basis for identifying practices that can support the use of the core technologies in each perspective for supplementing educational resources. The cited examples comprise a long-term comparative look at multimedia in education, yielding some of the insights shared in this report. The question of access is also examined with respect to these approaches. The purpose of this paper is to contrast and compare organization, presentation, and access to content with respect to education.

Introduction

Multimedia more than any other technology, has affected computing by creating a man-machine bond rivaled only by television. In attempting to extend the scope of computing in the direction of media, the form of integration and reach of the technology have also been extended. During this decade of multimedia and networking in education, a community (educational) of users moved from skeptical scrutiny of technology claims, to acceptance, to enthusiastic embrace, to prescribed use directive: the mandate to become connected, to become digital. Such dramatic change is worth analyzing. Tracing the history of multimedia in education provides a window of understanding into the technology forces that shape our lives.

This transformation will be exemplified in the sections that follow on the basis of real-life experiences with the underlying approaches. Our work for a Teachers' Workshop project puts into perspective the first approach cited, standalone multimedia in education. A Web-based project at a large university provides some rationale for the current emphasis on Internet connectivity. A third perspective, an experiment in digital libraries, discusses what is currently possible and what might become preferable in the near future. While many factors affect the direction technology will take, the natural acceptance of multimedia can be credited for where we are today, with technology in general, and possibly where (at least for now) we seem to be headed. This paper explores how this is happening.

Multisensory Media In Education

In its most fundamental definition the use of multisensory media in education is identical to multimedia in education. The rationale for using multiple media is to enhance learning by providing multiple ways to learn, using text and images, and increasingly, audio and video (among other means). Images, audio, and text provide interest, realism and mutual reinforcement of the learning process. In many kinds of learning, such as procedural skills, it is essential to exploit multiple media, in particular imagery, animation, and even video in order to demonstrate how to carry out some task or procedure.

The value of the multisensory approach, including the introduction of a personal computer to support some of the processes, was undertaken with serious consideration by the John Hopkins University Applied Physics Laboratory as early as two decades ago [1]. Today, the basic addition is in the use of a *multimedia computer*, that is, a computer equipped to capture and display all classes of media content in digital and analog forms. The use itself of electronic devices to incorporate media in education predates multimedia computing and would include the use of projectors, slide shows, VCR tapes, and (simpler or different) computers. We focus not on the vehicle, but on the approach to bringing these sources of information, this content in many forms, to bear on the educational process.

Multisensory learning does not require a computer. Obviously, before computers, teachers experimented in the combination of media content using paper cut and paste approaches to illustrate ideas. These early approaches have been providing results comparable to multimedia, albeit arguably with less efficiency, and much more limiting in scope and reach. Multimedia computing, therefore, in many ways relates more to function than to form. Digital multimedia provides opportunities for enhancing two basic aspects of educational use of multimedia: authoring and interactivity.

Key Features Of Multimedia In Education: Authoring And Interactivity

Multimedia in education is first a form of authoring, that is, integrating multiple types of media around an educational theme and objective, and making it available to students in a learning context such as a classroom directed by teacher, or a self-instruction situation driven by a student or student group. Authoring also provides a fundamental form of interactivity in the process of composing multimedia material, and then in the experience of using the educational material. Interactive software provides opportunities for other forms of interactivity when the multimedia composition includes programming logic that allows students to use and probe the learning module such as question-and-answer interactions, or researching material by following a particular trail of content around some self-directed interest. New forms of authoring and interactivity are emerging around computer simulations and laboratories where students can create micro-worlds of some physical or biological or social topic, and explore the principles and functioning of this world [2 & 3].

Authoring and interactivity also characterize non-computer approaches to using multiple media, but computers provide a potential advantage in supporting a more decentralized, and in some ways richer environment for learning. Digital multimedia learning environments will not replace teachers, but we believe they have great potential for complementing classroom learning and *inquiry-based learning* where the learning process is driven by student initiative, and involves potentially more open-ended learning situations.

Multimedia, now barely a (people) generation old, has been defined as the combined application of text, images, audio and video in a computer system. The essence of multimedia, however, is interactivity. It is sufficient to refer to multimedia publishing to elicit the thought of dialogue and interaction, man-machine interaction. The term multisensory alone does not imply that functionality. Interactivity is the hallmark of multimedia authoring, even though there is no succinct definition for the term *interactive multimedia*. Besides a form of dialogue, interactive multimedia is also strongly connected with hyperlinking, or the ability to interconnect various pieces of information dynamically within a given operational environment and content space. But the most significant aspect of multimedia in education is still related to authoring. The evolution of multimedia authoring as a form of computing has made it possible for students and teachers to *construct knowledge* and discover worlds that do not easily come to life on paper, or on the blackboard. The following is an example.

A Group Of Teachers' First Encounter With Multimedia

In the summer of 1992 a group of 28 public school teachers from the South Bronx in New York came to the IBM Thomas J. Watson Research Center for a first encounter with interactive multimedia. The group, organized by the Bronx Technology Assistance Center and led by Dr. Florence Mann, spent a

week in the laboratory learning not only how but why use multimedia in the classroom. The teachers were asked to work on projects and develop *folders* for Current Events, Critics' Circle and Trailers. They first learned the basics of multimedia authoring in a laboratory-classroom setting, using IBM's newly released (at that time) LinkWay Live product. They then split into groups of three or four, alternating between providing guidance on the projects and becoming students engaged in the creation of the folders.

For Current Events, the teachers collected and organized articles from the press and other sources. They created a multimedia archive, scanning and entering all information in the folders. The project included selecting the articles, summarizing them, critically thinking about the content gathered, and organizing the information in such a way that a perspective on the event emerged, supported by the evidence recorded and the analysis of the information. In Critics' Circle, the teachers played the role of film critics and documented their opinions about a movie. While some team members gathered content, others formulated viewpoints that were recorded and captured along with operative content. The "critics" prepared written and oral summaries of their opinions and made them available to the other groups directly from the multimedia folders. The clarity of their viewpoint, organization and quality of the supportive material, as made available in these folders, was all that their audience had to go by.

In the Trailers Project, the teachers produced an advertisement for a movie. Sequences of video frames and audio voice-overs were used to convey the message. Producing trailers highlighted important aspects of video production. The teachers also learned about commercializing a product and identifying market segments for it. Issues of choice, taste, trends and popular culture had to be examined and addressed. After one week of hard work (on their own time) and many technical and subject matter agreements and disagreements, the teachers went home, ready to become news anchors, film critics, and movie producers. For a while, none thought very much about teaching, they thought mostly about these trades, and applying what they had learned about them.

Critics' Circle Project Organization: Stand-Alone Interactive Multimedia

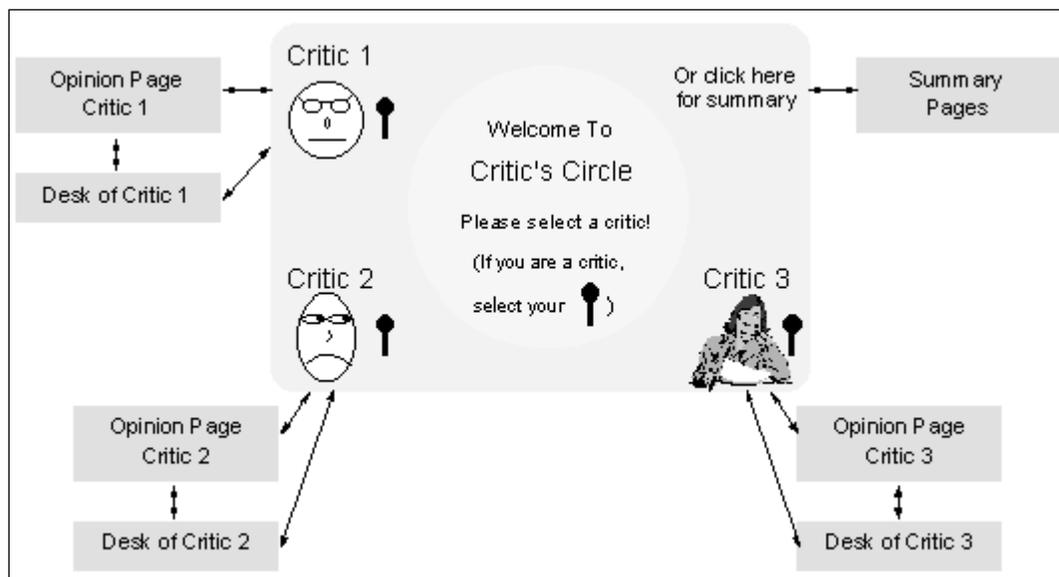


Figure 1. A group of "critics" work around a video and prepare their opinions folders.

From Pilot Workshops To Classroom Practice

The Teachers' Workshop experience highlights the vital role of *engagement* in learning. The workshop brought technology into a real-life curriculum. It gave participants the experience of being filmmakers and newscasters without leaving the classroom. Indeed, multimedia can make the classroom come to life. The rationale for this kind of learning seems clear-cut: the problem is how to move it outside of workshops and pilot programs into more routine classroom use, or how to integrate with curriculum.

One major obstacle is the technical demands of the computing environment. For the workshop, a group of IBM researchers prepared the perfect scenario for the experiment. All the computers were pre configured; all the parts were available down to the last RCA to BNC cable from Radio Shack. The software was up and running, and every processor knew exactly what model laser disc player had been attached to it and could play from it instantly and effortlessly. It was a technology heaven; these machines needed only to be powered on -- and they did something useful.

In addition, private offices were allocated for each group, so that the multisensory content with which our "researchers" were being bombarded did not disturb the other groups of "researchers" in the workshop, or the other researchers in the building. We were not able to silence general disruptions in the hallways or prevent unwanted invasions by uninvited wondering researchers who frequently asked the teachers, what are you doing? Dr. Mann had a very different question for them, why are you doing this? The technology was not novel, but such use of it was. Indeed, we ended up learning as much, about the use of multimedia in education, from the hallway discussions, than from the documented results of the experiment [4].

But all this carries a discouraging implication: multimedia deployment in the classroom is non-trivial, even when there is money and expertise to deploy it with. A minimum current generation configuration requires a computer with special adapters, a laser disc player, speakers, microphones, a video camera, sound recorder, scanner, possibly a CD-ROM for prepared content, and of course a multitude of software tools. None of this is cheap, and it is almost impossible to integrate coherently, except by professionals that do nothing but multimedia development. The average teacher, with other responsibilities to attend to, is at a distinct disadvantage.

This stand-alone approach to multimedia in the classroom has many pedagogical advantages in encouraging active student engagement, but it is difficult to fit into curriculum. A less open-ended and engaging approach, the integration of existing interactive multimedia titles (e.g., on CD-ROM) with curriculum is no less problematic. Professional developers in research centers, publishers, and large and small corporations routinely put out educational multimedia titles. This third party approach to design, development, and decision making relating to application (in contrast with our Teachers' Workshop approach) can only marginally involve teachers and students. It is thus not surprising to find significant holes in the quantity and quality of interactive multimedia titles available for education [5].

It has been argued that highly interactive multimedia in education is nonexistent, and that the failures of educational technology can be completely attributed to that fact [6]. But even if that problem could be addressed by serious efforts supported by major grants, the problem would still remain of how to integrate multimedia content even in its most practical form, CD-ROM titles, with curriculum. Today, it is still difficult in general to know what is available, to determine its applicability, and to actually link titles to educational relevance. It is even harder to tune material to specific goals and students' projects. Separating multimedia pieces in order to create new compositions out of source material is almost impossible. There are no "digital libraries for education" yet, but there is the Internet.

Expanding The Classroom: Networked Multimedia

Connectivity inside schools has been hastened by the need to manage information, especially for curriculum development. Driven by an abundance of content and a desire to share information beyond single schools, educational multimedia had to move beyond the limits of standalone technologies and local networks. In addition, the gradual appearance of computers that could display at least 256 colors, and play video, and the development of multimedia authoring tools friendly enough to be used by teachers and students led to content sharing and ultimately to collaborative uses of multimedia in education. Inevitably such applications require the deployment of networked approaches. Multimedia CD-ROM titles do not contribute enough to the use of *networked multimedia* because of licensing agreements that typically prohibit their transmission over a wide network.

Meanwhile, extended multimedia capabilities across existing infrastructures of distributed computing has been a reality for some time. It was back in the early 1980's that computers could handle only text and were not *user friendly*. But until recently Internet applications have been difficult to use (e.g., FTP and GOPHER), and used mostly text. With the advent of the World Wide Web (or *Web* for short), Internet access has become more available to non-technical people, and authoring of rudimentary multimedia documents (mainly hyperlinked text and images) easier. The Internet promises to provide a publishing space for sharing of ideas and for enriching the classroom with a wealth of information. But networked multimedia via the Web still has limits in the scope and reach of applications and their capabilities. Universal access to the Internet is still a problem. Hosting, authoring, organizing and finding, and sharing useful multimedia material are also problems.

For the production of multimedia CD-ROMs, authoring tools remain relatively complex and expensive in dollars and computational resources. On the lighter side of authoring, tools like HyperCard or KidPix are more accessible to teachers and students, but still require learning, and do not work well on the Web. Multimedia developed using even these simpler tools is difficult to incorporate into Web environments for networking purposes. Internet bandwidth still makes it difficult to easily transfer complex multimedia objects, particularly video. Therefore, multimedia production and Internet access to content remain somewhat separate and difficult to integrate.

The daily press reports classroom connectivity at 50%. But what does this mean? A teacher whose classroom is in the connected half complained at a recent gathering that her students get "a total of 15 minutes on the Internet to issue a query that could result in 14,000 hits." With not much time to find and download media, how much construction of knowledge can actually take place in the Internet environment? There is now a need for making our students *query literate*, a significant departure from our earlier concerns with *computer literacy*.

Use of the Internet in education signifies a partial departure from educational multimedia because of the weaknesses of the existing networks and the insufficiency of local storage to manipulate content. By these means, multisensory media cannot be brought to bear on the educational process as effectively as was done in the stand-alone model. The Internet would not easily support the kinds of content access and manipulations that our teachers were exposed to in that early multimedia workshop. Yet, content access and composition are now, in fact, Web-bound.

That is not bad news; a very large, very open authoring space is needed in order to extend the use of multimedia technologies to every subject, every project, every classroom and every student. But then, new tools are needed to organize and find source material and to construct new material on the Web. Multimedia cannot be fully integrated with the education process by means of stand-alone environments, CD-ROM jukeboxes, and content trapped inside multimedia titles. However, the Internet alone, as a world of online content and information, prepared in the form of Web pages, is equally not the answer: that is, "14,000 hits is too many answers." If the Web becomes a component in a larger

learning environment, with its own advantages and disadvantages, how then can we enhance the former, and reduce the latter?

Learning Via the Web

In 1996, as part of an English seminar class at Pace University, students, mainly sophomores, did what we called a Web Research Module [7]. One main point made, as premise to the project, was that some sources, though not good in the academic sense, might be valuable for their content, especially together with other sources. Never depend on only one source of information when doing research -- was the key lesson for our students. An example was the official Bob Dole Home Page. It certainly shouldn't be the only source, more objectivity is required, but when studying Dole, his real voice, if available anywhere, should be considered a primary source of information.

An assignment given to the students was to work together, in groups or two or three, collaboratively exploring topics related to their major field of study, global in nature, and personal (perhaps a hobby). The students were to use at least two search engines for each topic and identify and describe sites recommended in their field as well as non-recommended sites. The completed assignment was to be submitted as a report prepared in HTML form, with links to all the sites mentioned. The students were also encouraged to use VIEW and to learn other HTML tricks. The students came to understand that they needed to assess what they were seeing. No other criteria would be available to guide them, but their own judgment of the content on the Web.

In terms of *process*:

- Independent thinking
- Critical thinking
- Inquiry-based learning

In terms of *mechanisms*:

- Organization of ideas
- Writing and composition
- Presentation

Structure of the Web Research Project:

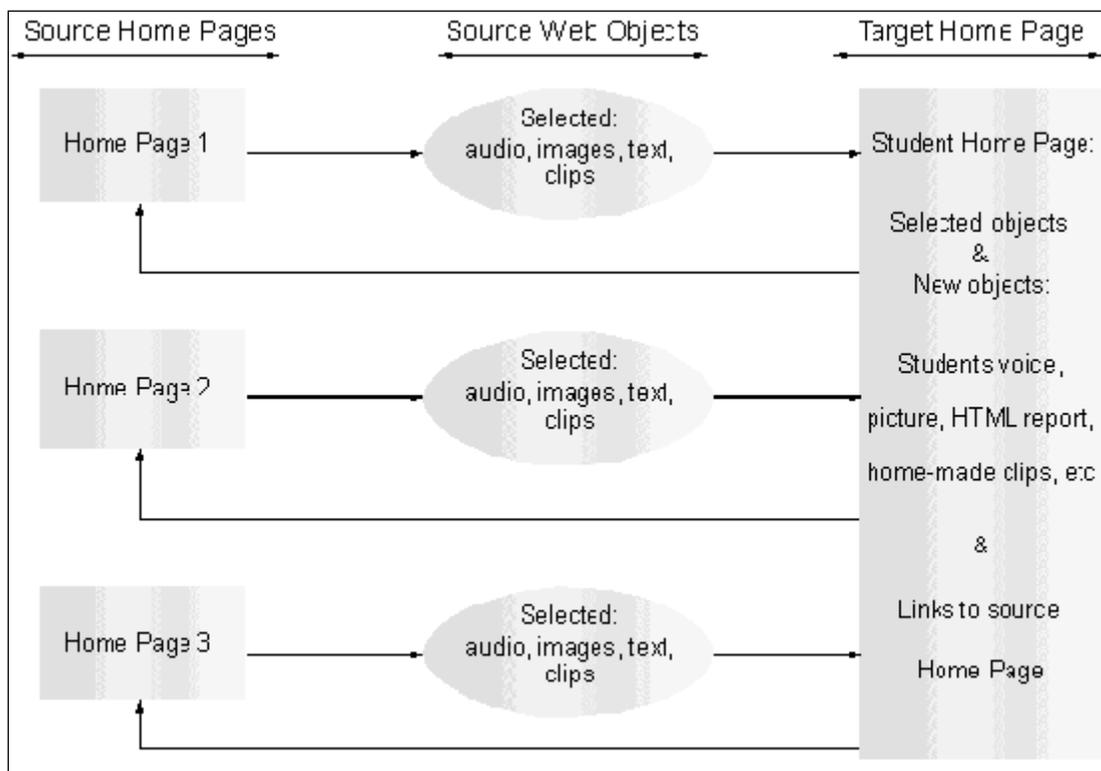


Figure 2. Students find content in the Web and prepare their research report as a new Web page.

Comparing Notes

For the Web Research Module, students were implicitly required to be inquiry literate, that is, to find information relevant to a learning objective, and discriminate between useful and less useful information in a large search space of information [8], on the Web. In contrast, in the Teachers' Workshop project, the instructors created a more structured environment of base material. Using this material well within the established instructional goals, required creativity and insight. In both cases, students had to create (author) a report conforming to a genre (Web document vs. multimedia folder). The projects had different goals, and different constraints and emphasis, and represent two different but equally important skills: authoring or reporting, in the Teachers' Workshop, and inquiry or research, in the Web project.

The Web search project was more open-ended with respect to finding source information. Two schools of thought developed during the course of the Web project, about two opposing but equally strong tendencies in inquiry. One is the optimistic view that access to sources of information (in this case, the Internet) will automatically bring significant improvement in learning to all students: students just need to "plug-in", and teachers can retire. The other view is that since the Web is not organized, vetted, edited, and reviewed, and since much of the material is essentially self-published, it can serve no useful purpose in education. Our view is that the Web can serve many significant purposes for teaching, and learning, and its very unevenness can be utilized by teachers to promote critical thinking. In the longer term, new technologies and practices can improve the quality and accessibility of information on the Web.

Digital Multimedia Libraries

The classes of tools that have come to be called *Digital Library* have the potential for providing some of the organizational capabilities of standalone environments with the *open-endedness* of the Internet environment.

These capabilities include functions for:

- Capture, composition
- Storage, naming, management
- Transmission, transformation
- Organization, indexing
- Query, search, retrieval
- Sharing and collaboration

Various products are on the market today that supply one or several of these functions. But digital libraries promise much more than a foundation for the information age. Technologies imbedded in digital libraries are enabling a major shift toward more powerful ways for users to find and organize information. Examples include searching by different types of search criteria, including metadata categories and attributes, as well as by text content, and even image content. Free text search over text holds great promise for finding information based on content, and on not attributes chosen and specified by other people. Where human labor and intelligence are available for creating metadata about a collection, there are opportunities for enhancing organization and search according to criteria targeted to specific needs and goals, such as education. For example, the criteria could be curriculum goals, or research goals.

But the ultimately, the value of these multiple forms of indexing and searching in digital libraries rests in their contribution to the success of students and educators in harnessing useful information. Still, the

interrelationships among data objects in large warehouses *of content* will become complex in proportion to the users of the content and the amount of content that is aggregated over time. As a result, object management will become very complicated. Object managers in the digital library environment are being developed that will address these problems. Digital library storage, indexing, and search technologies provide only the most basic building blocks. As most management tools tend to be application dependent, for digital libraries a content organization layer will be required to put content into educational context.

Putting Content Into Context: The EduPort Project Approach

Multimedia data definition, organization, storage, and navigation can all be supported by means of databases. Multimedia warehouses require context management in addition to content management. In a recent experiment, a multimedia digital library was made available to a school from a large media server over a fiber network. Since 1994, Project EduPort [9] has provided a testbed for networked multimedia in the form of a digital library. Context management can take the form of a *framework* for the use of multimedia in a particular application area. In EduPort, for example, the application framework includes not only a library of content but also a corresponding library of information about content. That is, EduPort focuses on classes of information that relate to how to use *multimedia objects* as a part of a project, lesson plan, student portfolio, etc., on the basis of the experience of educators and students. This information becomes a new layer of stored content, as a layer of metadata for characterizing both.

Original source material

New knowledge and media obtained from the use of the source material

This evolving layer of new material reflecting an ever-broadening range of uses and experiences makes the environment relevant and participatory. For each *media object* there is a separate *data object* that contextualizes the media with respect to real classroom use and evolving curriculum objectives. That information is very useful for retrieving the appropriate object and for combining it with other objects in interesting ways. In the case of video objects, such contextual and descriptive data is almost indispensable.

EduPort must rely on new generation digital library search tools to make the best use of the available content in an eventually infinite digital library authoring space. However, it is because of the organization of EduPort content and the way in which the content is indexed that such tools in turn become useful in harnessing the content. Combined research in content organization and content searching, is posing some interesting questions about generalizing organizational schemes for multimedia authoring within a digital library framework. But there is another consideration: equity access to content, as a function of quality and quantity, not just connectivity.

Window On The World

The following section was extracted from a magazine article, [10].

Teacher Celine Robertson greets her third-year Chinese language students and directs their attention to a large white screen in the corner of a spacious dimly lit classroom. Holding a tiny black remote, she pushes a button, and instantly a menu appears on the screen. From a host of subjects listed -- science, mathematics, history, and the arts, among them she selects number seven: Chinese.

After navigating quickly through another set of menus, a young Chinese couple appears and begins talking in Mandarin. The students listen attentively to a few seconds of conversation. Then Robertson pushes another button on the remote, and the action stops, a clear image of

the man with his mouth wide-opened suspended on the screen. Robertson, in polished Chinese, prods her students: Who is this man? Who is this woman? What is their relationship? The students respond. Pleased, Robertson pushes the button again, and the encounter on the screen continues. The interactions last only a few minutes, but Robertson, through a series of stops and starts woven seamlessly into her lesson, uses each as a springboard for class discussion.

The EduPort Content Framework

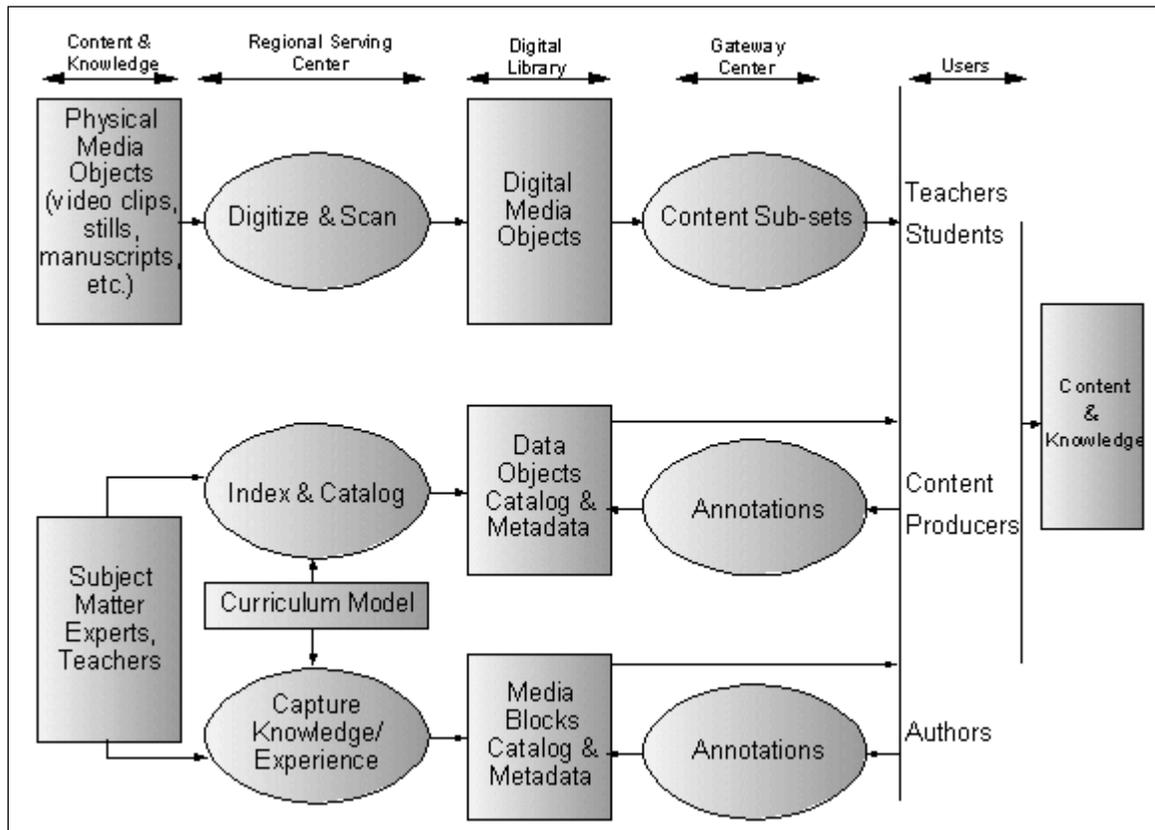


Figure 3. Content and context are separate, leading to re-use of content, and systematic tapping of new knowledge about content.

The Concept of a Library Without Walls

In a way, EduPort is a library and museum without walls. But it is more than that: it is an open window on the world. When EduPort was presented to the students and teachers of Lincoln High School, in Lincoln Nebraska, there was no Internet access in the school, and the Web was virtually non-existent. Yet what Ms. Robertson was able to do in the spring of 1994 is still not possible in any school now connected to the Web. In this example, by increasing the scope of the content space, from stand-alone to localized distribution, the functionality of the environment (now a digital library), was increased. But, by increasing access beyond a given localized digital library, to the Web, as in the previous example, functionality and content access were reduced. The system, a prototype for a K-12 digital library, was a demonstration of what might be like to link educational goals to content in lesson plans alive with material, most of which was video. One of the goals of the project was to create an environment that would require one minute or less of teacher training, nevertheless enhancing the classroom with rich content and dynamic access. By the time his Chinese lesson was over, the students had become experts in the use of *interactive television*, something most had never experienced before, but were

born to master. The lesson learned is that this approach is not only doable, but it gains quick acceptance. We need not constrain the richness of content that can enter our classrooms and homes, and if we don't, the content will be used profusely. But unfortunately, there are other serious issues to consider, beyond usability and rich media.

One significant difference between the EduPort experience and the other two projects (based on stand-alone multimedia and the Internet) is in the way the information is organized. The organizational framework provides the foundation for generalizing multimedia authoring in a participatory environment. It also provides an opportunity to address issues of access. A major problem with the Internet, in making accessible rich content, is limited bandwidth. EduPort was demonstrated over a high-speed intranet. However, content organization and presentation in EduPort, while suitable for Internet delivery, make it an approach also suitable for *Digital Broadcast Satellite* (DBS) [11] delivery, a transport solution that has the potential to change the dynamics of (equitable) access for all students [12]. In most cases the opposite is not true. That is, the way in which most Web pages are being constructed, encouraging open surfing, and intensively using text, is inappropriate for DBS access. Multimedia design is an issue. A multimedia folder or CD-ROM would have to be recoded for the content to be used as a Web page. Most Web pages would have to be redesigned for DBS. The way in which content is organized and presented is potentially the key to leveraging this new transport solution [13]. The strength of EduPort is, therefore, a function of the capacity of the media server used, the bandwidth of the network employed, the richness and scalability of the content enablement approach, but most importantly, its transferability to DBS within this integrated and broad level of functionality.

Content Preparation for Digital Broadcasts

Use of the Web requires *browsing* or *surfing*, to find content, even after limiting the content space with a search. That is not unlike what people do with TV channels, except for the fact that in the TV model the content space is limited a-priori. The broadcast model coupled with the Internet, however, can provide a more equitable solution in terms of content quality and access. Unlike the point to point connectivity model of the Internet, the digital broadcast medium can be used in real-time or in download mode to broadcast, multicast, and PointCast educational content on a much larger, global scale. Digital broadcasts can fully complement access to the Internet or can be deployed stand-alone (without a terrestrial network).

The nature of the medium and the characteristics associated with the player devices (TV and remote control) do not require explicit control by the educator, only guidance relating to the selection of material. That is, available material are scheduled or requested a-priori by the educator for a given time span during which the material are available. These time spans can correspond with curriculum models, special services, or place and time of day. The solution mirrors access as deployed in EduPort for a local environment. Content presentation in EduPort maps to this solution as well: remote control and TV screen, as opposed to mouse and PC monitor, a different look and feel. Content organization and presentation differentiate what is suitable for both Internet and DBS access and what can only be accessed via the Internet, something to consider. As DBS technologies advance are deployed more extensively for education, these issues will become clearer, and applications will be developed to take advantage of this powerful medium of content distribution. Tools for adapting Web pages for such use will very desirable.

Metadata in Multimedia Libraries

An integral part of multimedia in digital libraries is the metadata associated with each media object. In all cases presented, the media objects alone are not sufficient to create a framework for their use. In EduPort, content is organized thematically, by curriculum standards (concepts and benchmarks) and indexed by classes of information (descriptive content abstract, visual abstract, audio transcript, annotations). A similar approach could be used to deal with content in a different domain, mapping the

constructs to the particulars of the application area. Generalizing such schemes would significantly improve *content mining* approaches. To date, multimedia content in education has not been officially categorized (as a standard practice) in any domain, making this possibility remote. For education, with this in mind, we propose that: type, purpose, and subject are the most useful categories for describing content. Every multimedia object has a type, a purpose and is part of a subject. Type, for instance could be used to determine if the media object is an entity or part of some entity, for example, a multimedia title. Purpose refers to the intended use of content (by its creator), as opposed to the given use, at a given time. For example, in EduPort, an art teacher to illustrate patterns and inspire creativity in a jewelry-making class later used a fractal image used to describe the mathematical theory.

Use will always change the type and purpose of content. Here is an example. The video "Feast of the Gods", from the National Gallery of Art was digitized and included in the EduPort digital library in its entirety. The metadata document associated with this video included extensive information about the content. Subsequently, a teacher isolated a short clip from the video, which was then indexed separately, dealing with the use of "Scientific Instrumentation in Art Restoration." This new title reflects the purpose of the new type (a clip which was part of the original video). The new purpose relates to the role of science in art. This re-purposed material, in turn becomes part of the EduPort library as a separate entity. It can then be combined for use in a completely different subject domain, with other previously unrelated material. These possibilities make digital libraries in education a promising approach [14].

Categorizing content by use also raises interesting perspectives on content organization. The definition of abstract classes of information to separate content from context, and from application, begin to formulate a general-purpose approach to content characterization. In EduPort, this characterization, while restricted to the domain of education, makes content more useful, because it can be used in different ways. Standards for characterizing content could become as fundamental as the standards for digitizing it.

Content Classification in a K-12 Digital Library:

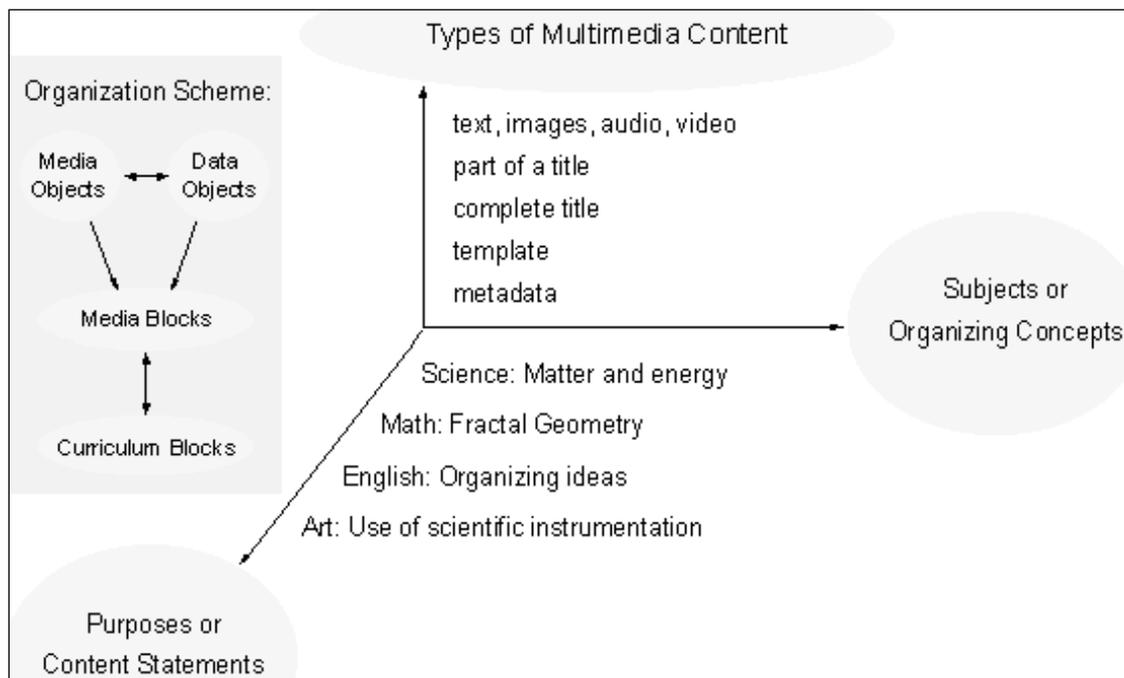


Figure 4.Content characterization leads to coherent content organization schemes.

Summary, Findings, and Conclusions

Multimedia technologies, at least in education, have evolved from standalone use, to networked use, to the exploitation of new capabilities in digital libraries. This will lead to the content warehouse approach where information about content will be as valuable as the content itself, maybe more. The current trend of unbundling content (from CD-ROM to object repositories), exemplified in part by digital library approaches, is not the final stage in this evolution. Searching by, and then fragmenting content into pieces, even single objects within a given object (pieces of an image, selected frames from a video clip, paragraphs from a document, etc.) indicate that there is need and desire to use multimedia in selective and re-constructive ways.

The ability to index in very specific and detailed ways with respect to content will facilitate data mining. The ability to index with respect to context will facilitate authoring. Both will increase the value of the content, and the value of the metadata generated to exploit content in this new warehouse approach may exceed the value of the content, by far. Because of this, techniques, not only for indexing, but also for organizing content, so that it can be more effectively used and reused, will become valuable technologies and necessary tools. Enhancing the quality, variety, and speed of media delivery options is turning into a race. In the projects presented, we have seen the emphasis moving from strictly speaking *interactivity*, as a form of (pre-designed) dialog between users and content, to (unanticipated) manipulation of the source content itself to support *creativity*. The new multimedia environments (Web and digital libraries) support more of the kinds of spontaneous authoring that encourage creativity.

A fair conclusion is that the Internet is taking educational multimedia authoring, and education in general, closer to the *telecommunications industry*, while the desire to apply more, and more varieties of media, seem to be moving educational multimedia closer to the *media industry*. The advent of DBS and the anticipated development of tools and techniques for exploiting its potential for education will hasten that trend. All this is leading to a shift in the creation and design of educational material, from *professional authoring* to *public authoring*. And eventually, we may see the further evolution of educational multimedia, the product of the *publishing industry* into a form of *telecommunications and media* product. The contrasts in projects like these, and the direction in which this evolution is moving, for now, suggest that educational multimedia could turn into an extension of the media industry alone, or more precisely, it could integrate, rather easily, with (digital) broadcast television.

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