Roles for Digital Libraries in K-12 Education

Miriam Masullo and Robert Mack
Thomas J. Watson Research Center
IBM Research Division
Yorktown Heights, NY

D-Lib Magazine
http://www.dlib.org
September 1996

Introduction

In this article we examine the question of what roles digital libraries may appropriately play in K-12 education. The EduPort Project [1] has provided a research testbed for exploring those ideas and testing some of the possibilities. In the context of digital libraries how to transform atoms into bits is a technical problem being addressed by much research and development coming from both industry and academia. The problem is how to tap into the kind of knowledge that teachers possess and how to gather content of the kind useful in learning. That problem is best addressed by means of dedicated demonstration projects that specifically target the education issues and the educational settings.

There are important reasons why. A warehouse of digital materials organized and exploited in the form that is now referred to as "digital library" represents a new resource for education, as it may in other domains. The flexibility of a digital library and the richness of the tools now being developed to exploit them invite exploration of content. Exploration in education is generally rewarded by discovery, enabling inquiry-based, and constructivist approaches to learning. However, digital libraries also represent a functional departure from our existing technology-supported educational environments. This constitutes a risk, since the greater the functional departure, the more difficult that it becomes to make changes pervasive, thus lessening the chances for revolutionary and moving closer to evolutionary changes.

In education, we seem to want both a revolution in education and a simultaneous paradigm shift to advanced technology. These goals may be in conflict. Massive and immediate change may be possible within the context of digital libraries in education -- if the culture and curriculum of schools is somehow preserved. In the remainder of this paper, we examine aspects of digital libraries that hold some promise of bringing about the realization of both goals.

Transforming Knowledge into Digital Content

Moving from a hands-on, real-life learning experience of substance to a digital version of it presents many interesting challenges. Depending on what the goals are, several models are possible. For example, one goal might be to replicate the learning process with the aid of technology, recreating the learning experience using a computer. A very different goal might deal with capturing knowledge about the experience itself, so that it can be replicated either in its real-life form or using technology. In both cases, the suggestion is that there are ways of moving knowledge, experience, information and content from conceptual and physical forms to digital representations. The different kinds of possible transformations, from physical to digital form are

linked to and suggest the different roles that digital libraries can play in education. The following example illustrates the idea.

Cardboard Kayaking: An Interdisciplinary Learning Experience

Cardboard Kayaking was designed, developed and implemented as a three week long challenge-based learning experience by Ms. Debbie Faigenbaum, a teacher at San Francisco Community, a school in San Francisco, California. Based on the approach of the San Francisco Project 2061 [2] curriculum model, the challenge presented to each of nine groups of students was to build a kayak using only plastic tape and a piece of 4-foot by 7-foot cardboard. The richness of the interdisciplinary experience is described in Figure 1.

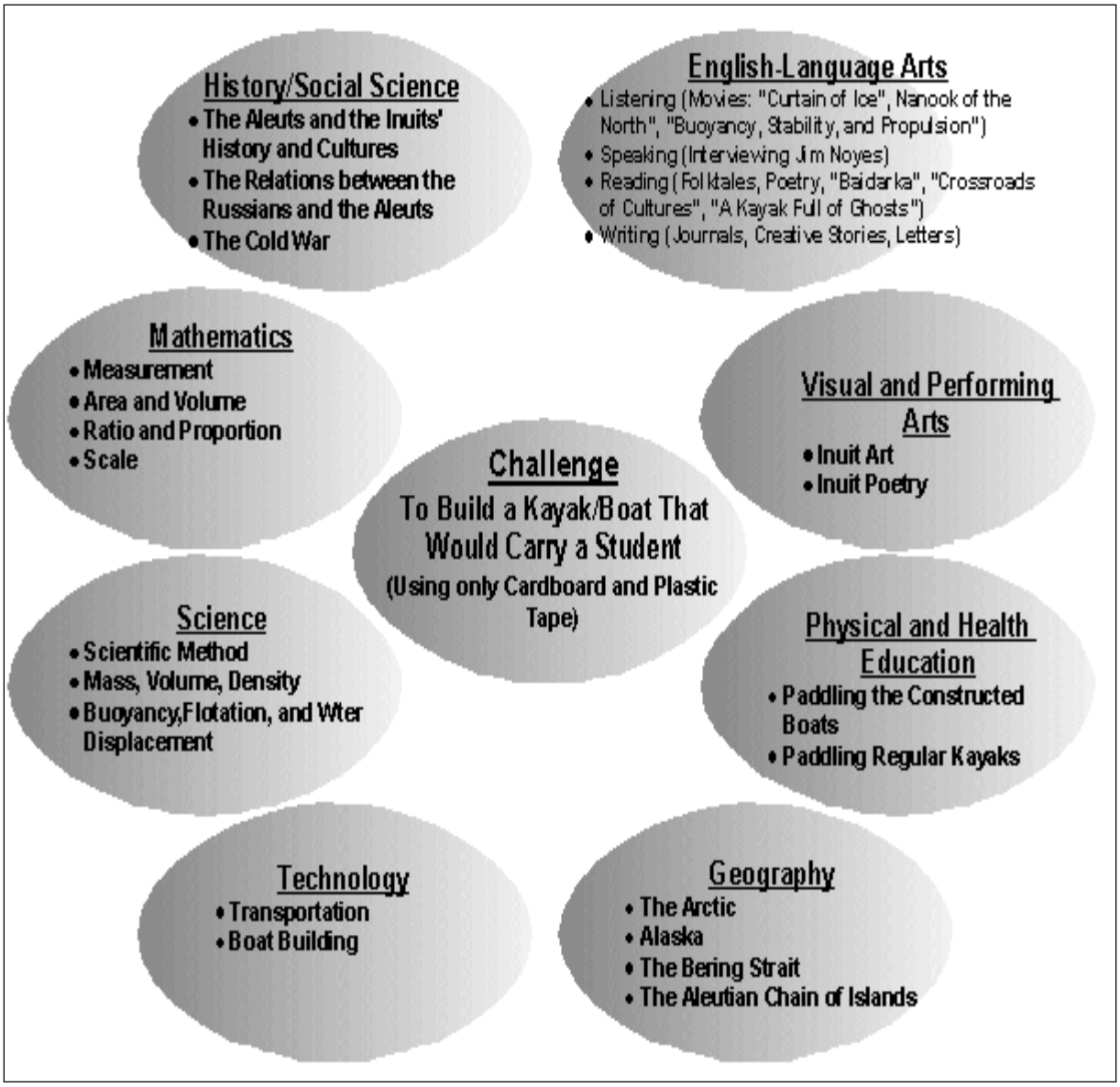

Figure 1. Diagram of the Cardboard Kayaking interdisciplinary experience.

Twenty-seven students in fifth through eighth grades spent most of the learning experience working in groups of three. The students were asked to make something that floated out of a piece of cardboard, and then to predict and test which models would float. They first built play boats and floated them with marbles to determine and test how much weight they could carry without sinking. They engaged in the scientific method, experimenting, observing and measuring water displacement, formulating and testing hypothesis about buoyancy.
The students designed and created models of boats using measurement skills and mathematical concepts such as areas, volumes, scales, ratios and proportions. Finally, each group of students built a real boat. Students also learned about early kayak users, the Aleuts, and studied the history, culture, and geography of their region. The students found first-hand accounts of the meetings between the Russians and the Aleut people in the early 1700's and wrote creative stories prompted by the question: pretend you are an Aleut, how did your first meeting with the Russians go?

The culminating experience consisted of a one hundred yard race in Richardson Bay in Sausalito. Before starting the race, the students advertised the designed features of their respective boats including the Inuit art on the sides of their boats and read poetry in front of the other students and their parents. All boats ended up floating, some carrying up to two students. The learning experience was in itself a test, using specific criteria and standards to explicitly document student learning. The students kept journals and assessed what they felt they had learned and expressed much enthusiasm about this interdisciplinary learning experience. Not surprisingly, feedback from the parents confirmed how positive they felt about this challenge and real-life approach to the curriculum.

From Capturing and Deploying the Experience to Creating New Ones

The Cardboard Kayaking experience raises many interesting questions regarding how far we can go with interactive multimedia to elicit and motivate the kind of learning that took place here. This is a particularly rich teaching and learning exemplar, and therefore, it poses more challenges and more possibilities for the application of technology, ultimately of digital libraries. The most obvious aspect of the project that can be captured with multimedia technology is documenting of the teaching exemplar itself, so that other teachers can re-use the ideas and the preparation that was done by Ms. Faigenbaum. Photographs, and videos that captured and recorded the progress of the project can be digitized, and teacher guidelines and plans can be written up and included in the multimedia document or folder. The curriculum benchmarks that were addressed can be listed and explained, as well as the assessment criteria, findings and results from the project. In short, through the use of scanned or digitized media, and a multimedia-authoring tool, this and many other teaching exemplars can be captured for the benefit of other teachers and students. It is not hard to imagine how such a collective resource, at large, in the form of a digital library can be a powerful support mechanism for our schools.

A second, and more difficult job would be to replicate the student's learning experience using mostly a computer interaction model, that is, implementing the experience with interactive multimedia, so that students can benefit directly from the experience captured in digital form. Digital media and an authoring tool would again be required for implementation. Issues that affect implementation of this model include level of interactivity attempted, amount of functionality, portability, ease of use, etc. In both cases, the task is to capture an existing experience or activity for one of two interrelated purposes: teaching and/or learning. The task of

originally creating such an experience, in the digital domain, would also relate to multimedia authoring, but defines a third distinct scenario, publishing.

That possibility raises even more interesting questions:

- ✓ Would Ms. Faigebaum have been able to create such a rich educational experience had she started out in the digital domain?
- ✓ What is the difference between software titles originally designed and implemented for use by means of computers, and those that might be created after a real-life experience such as Cardboard Kayaking?
- ✓ Which classes of experiences can software titles and/or digital libraries target more effectively?
- ✓ What are the differences?

Computer-based approaches to Constructivist Education

Computer-based approaches to constructivist education attempt to answer questions like these affirmatively. These tools have been an active area of research and classroom use for well over a decade (depending on how one defines this genre of computer-based software) [3 and 4]. These tools cover many aspects of the learning experience including ability to measure, record and analyze data; to create models and simulations of real-world situations; to support collaboration in accomplishing computer-based projects, and to devise authoring tools for creating reports and presentations of project results. These computer-based learning tools complement and enhance in-person and hands-on student projects in the classroom. They provide tools for collaborating remotely and for sharing results and ideas across geographically separated sites, and let students use multimedia to create presentations and reports.

These learning tools are valuable. But they also tend to be specialized in terms of the specific learning topics (e.g., science and ecology), and the software environments needed. The EduPort project exemplifies another and complementary dimension of learning environment: providing wide and easy access to teachers via the Web to an open-ended and evolving repository of pedagogically relevant multimedia source material which educators (and students) can use in classroom curricula and projects. This approach does not focus on providing specialized tools and frameworks for achieving specific pedagogical objectives, but intends to provide access to source materials, and a framework for Web-based access and collaboration. More specifically, a framework for the development of information infrastructure for education, that can be implemented collaboratively and be tailored individually for use by teachers and students. This approach is consistent with the common ground for information sharing concept upon which the Web was designed.

Roles of Digital Libraries in Education

Creating, capturing, and deploying a learning experience are all activities that can be conducted in the digital domain. These drive fundamental requirements for the application of digital libraries in education, and maybe also define some of the most important roles they can play. However, moving from a stand-alone to a global networked digital environment, and from a contained resource to a universal opened content space, that is moving from educational computing to digital libraries in education requires new strategies and rethinking the role of technology [5].

Analysis of the Cardboard Kayaking example clearly identifies at least three roles that digital libraries can play in education:

1. As a resource for teaching (curriculum development)
2. As an environment for learning (student experience)
3. As authoring space (again, in support of student experience)

Models for the application of digital libraries in these scenarios can be made to exploit the characteristics of the new environment. But furthermore, they can be applied to revisit and support the current constructivist approaches to computer-based learning.

An Organizational Model for the Use of Digital Libraries in Education

EduPort uses a content organization scheme [6] meant to take advantage of the openness of the digital library collaboration and authoring space. Modular pieces of content, referred to as Media Objects, in the form of digitized video clips, scanned images or text are stored in an object library and accessed in real-time on-demand from a media server. Information associated with each Media Object is kept in the EduPort Home Page, deployed as both catalog and user interface, and accessed from the EduPort Web Server.

Information about an interdisciplinary experience, teaching exemplar, student projects, etc., identified as a coherent entity, composed of content and knowledge relating to how the content is being used in each case, is also kept in the EduPort Home Page. These are referred to as Media Blocks and are loosely related to Curriculum Blocks in the content of the Project 2061 Curriculum Models, of which the San Francisco Curriculum Model is an example. A Media Block characterizes the content thematically and relates it to specific learning goals. Information that binds content to curriculum is contained in the Media Object and employed by the Media Block to exploit the content.

In the case of Cardboard Kayaking, for instance, this modular approach would allow a teacher to combine content from topics such as English and language arts (interviews, poetry), visual and performing arts (Eskimo art and poetry), history, and social science (the cold war, Eskimo art and history), etc. The possibilities are numerous, even within a single learning experience. A digital library would facilitate drawing content from diverse sources to illustrate and re-enforce the many aspects of learning experiences such as this one, and encourage their development and deployment. But the real value added comes from re-use. Teachers do excellent work of bridging materials to create rich learning experiences. It is very difficult, however, to share the results with other teachers, and only a handful of student receive the benefits of unique exemplary teaching in each case.

Opened and networked digital libraries offer that opportunity. The content in turn can be re-used by other groups working on completely different learning experiences. So, for instance, the mathematics (ratios, proportions, areas, volumes, etc.) and the physics (mass, weight, density, buoyancy, etc.) contents of the Cardboard Kayak experience can be re-used or even used simultaneously in a different project relating to transportation, for example. Being able to look at the same content in different ways makes that content more valuable. In EduPort, information about content can be annotated at any time (via the EduPort Home Page), allowing teachers and students to share their knowledge and discoveries. This enriches content in ways that pre-packaged, pre-created materials, as is typical of software titles, cannot support.

The EduPort Digital Library Framework

What makes EduPort Media Objects useful is the information about how they can be, and have been used in the context of curriculum. This self-awareness of each object with respect to their own usability is key to deployment of digital libraries in education. The problem addressed is that of finding a suitable organizational scheme that works well with the content representation and content dissemination schemes deployed [7]. With a digital library, we have new opportunities for exploiting content, but not if the content organization scheme deployed repeats the stand-alone or local sharing (relating to dissemination), and the bundled approach (relating to representation) of interactive multimedia software. Figure 2. illustrates how these issues are tackled in the development of the EduPort Digital Library. In EduPort, the content is the theme, and it motivates thinking about how it might be used.

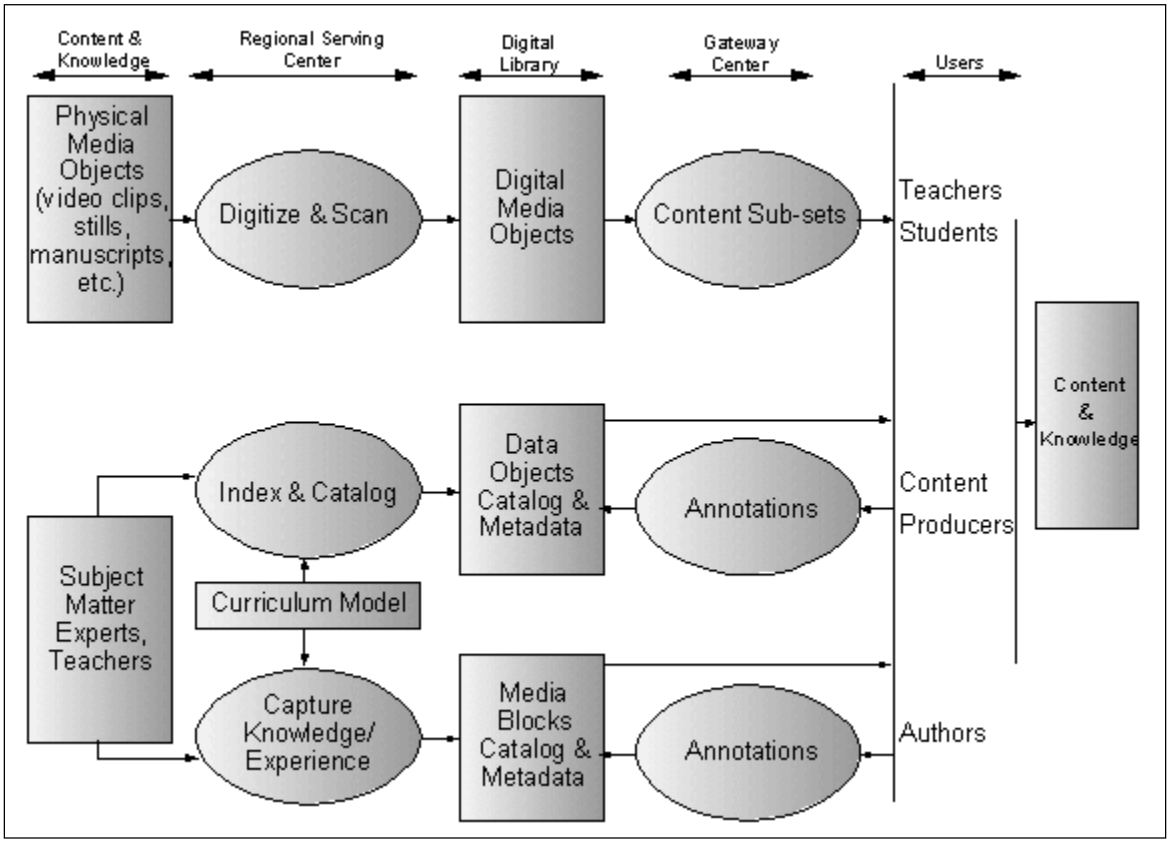

Figure 2. Content flow in the EduPort Digital Library.

An Approach for the Use of Digital Libraries in Education

Several years of prototyping the EduPort vision demonstrates the wide availability of public domain materials available from government, academic, and cultural institutions. The key problems are capturing this material in digital form (e.g., digitized videos, scanned text descriptions of videos and images), organizing it so it can be found, and developing some level of tools for re-using this material in new pedagogically relevant ways. The emergence of the World Wide Web and of technology and products to support the creation of digital libraries

provides the means for solving these implementation problems and moving towards achieving the objectives of EduPort. But, how can we implement such a vision on a large scale? We believe an effective start can be made by exploiting not only the existing Web, but also key aspects of digital library technology as it is emerging in industry and academic research labs, and in product-level technology in the computer industry.

Digital library technology covers many issues, and not all are relevant in this educational context. However, four major EduPort requirements map well into this technology:

- ✓ Hosting multimedia information
- ✓ Making it accessible via search and browsing
- ✓ Supporting certain kinds of collaboration, e.g., feedback about digital resources and re-use
- ✓ Using the Web as an end-user interface for these capabilities

We know how to create indexed collections of multimedia information and make this available via the Web. Access to information means being able to search for information by keywords, bibliographic attributes, and terms matching the text content of information. We also want to organize material around the EduPort organizational schemes that support browsing of summaries of material in ways useful and familiar to educators: for example, learning subjects, curriculum objectives, schools and institutions, geographical location, etc. We know how to create multiple types of indexes that support searching on fixed attributes (e.g., keywords, author names, titles, etc.) as well as free-text search on text content.

Pedagogical relevance is a function largely of the creativity and skill of the educators that use the material. But the goal of EduPort is to support re-use of teaching resources by reflecting teacher's experiences with materials acquired from EduPort back into the way EduPort material is indexed and categorized. How information is searched, how it can be browsed, how it is interconnected within EduPort will become a function, over time, of how teachers use it, how they describe their uses to other teachers, and how this feedback is used by the EduPort system to incrementally extend the indexing and organizational attributes of EduPort material.

Finally, with respect to end user access using the Web, we know how to build dynamic Web pages automatically from templates to let users create query specifications, use Web pages to submit descriptive text information to an on-line library, show collections of search results, and display the contents of result items consisting of multiple media items (e.g., text and images). The EduPort approach to collecting and making available digitized multimedia source material is complementary to computer-based learning systems focused on specific learning topics and approaches, specialized tools for authoring, record keeping and network collaboration. We see EduPort as providing a broad-and Web-based foundation for supporting curriculum development based on digitized multimedia information. Using a Web approach makes these electronic resources widely sharable by eliminating specialized software and reducing software development.

Of course, existing digital library technology only provides the raw building blocks for such multifaceted applications. Current technology focuses mainly on capture, index and search of multimedia information. How these building blocks are used will take much creativity and will evolve with use by educators and even students. In particular, additional tools for enhancing electronic collaboration, and authoring of courseware based on source materials will be required.

Over time, we believe that the EduPort based approach can be effectively integrated with specialized courseware to exploit the advantages of both approaches.

Concluding Remarks

The simplicity of the organizational scheme and approach presented must be accompanied by robust technology solutions; to support both the required scalability and functionality needed to make a digital library system useful. EduPort deploys an industrial strength media server and Web server, to support large quantities of content and large numbers of simultaneous users. Network configurations are also taken into consideration. Infrastructure is essential to deployment of digital libraries in education [8]. That aspect of the project is not what we consider essential to its mission, although an important part, if we value equity access.

With respect to educational content, however, taxonomy specially designed to classify media with respect to curriculum in digital libraries, would greatly enhance the processes of search and retrieval, and support the constructive approach to learning in ways that existing software development approaches cannot. That, combined with specially designed search, retrieval and composition schemes, offers truly new opportunities for teaching, learning, and authoring using knowledge and information. Content in a digital library can be made to embody that kind of knowledge and information that is so vital for learning. It has been said that information is not knowledge, and that knowledge is not wisdom. Digital libraries in education can be made to change that perception.

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