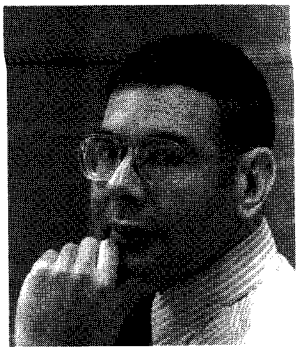
Journal of Information Systems Education

Fall 1994

Reengineering Education



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1. INTRODUCTION

The role of Information Systems (IS) is to develop, implement and maintain technology that increases the value of a firm. This role has been deeply affected by the changes in all aspects of technology: computing, communications and telephony, since the very birth of the field. As the uses and capabilities of computing and communications technologies have exploded exponentially in the last decade, IS practitioners and researchers are constantly grappling with the problem of designing and developing applications to increase organizational effectiveness.

One constant in the past upon which IS people could rely to be relatively stable was business processes. The basic processes that corporations use to perform work have been relatively static over the last fifty years. Recently, though, the overpowering assault of technology has forced the conservative and technologically backward upper echelons of organizations to fundamentally reorganize their business processes to achieve greater operational efficiency and agility. The need for greater speed in reacting to events emanating from the business environment typically results in a decrease in middle management, which is visualized as hampering organizational flexibility and not contributing directly to the bottom-line. We often read in newspapers and business magazines that companies are reducing their workforces by the thousands to compete in the global economy and market environment of decreasing profit margins.

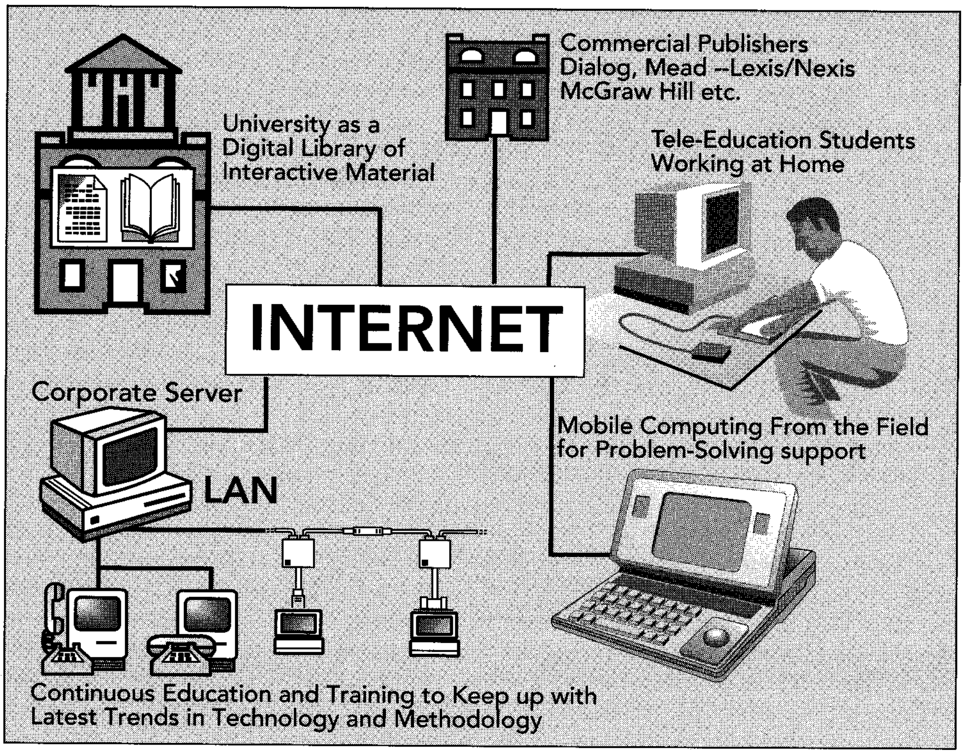
Lean and mean is the battlecry of companies seeking increased market-share and competitive global positioning through reduced operational costs. Why do companies believe that trimming their once highly valued, well trained, middle management is the correct way to achieve greater profitability? One answer is that what once happened to blue collar workers is now happening in the white collar sector replacement of human capital with technology to further the goal of improved organizational effectiveness. The blue collar worker's technological nemesis was highly automated manufacturing plants and an increased reliance on sophisticated machines. For white collar management, it will be sophisticated software systems built on a corporate wide computing infrastructure. These systems will free managers from the shackles of tedious and time-consuming bureaucratic tasks, enabling them to channel their efforts in productive and creative activities, such as information gathering, decision-making, coordinating, learning and information processing. Such a manager becomes a flexible, responsive asset who will enhance a company's effectiveness

Organizations, especially top management, see technology as an instrument that can be wielded at will to reduce costs. Technology, especially network-based computing, has given management the tools to change the quality of the work, (e.g., customer service quality), not just its speed of completion or rapidity of repetition, (e.g., assembly line production). These new developments have a profound impact on the way we educate our future graduates in the universities and provide on-the-job training to the workers in the field. Continuous or lifelong education is becoming necessary as it is impossible in our changing economy to impart an education of ever-lasting value or impact.

In this article, I will use my three decades of teaching and research experience in the IS field to articulate and speculate on the directions towards which we should move in order to meet these new challenges. In particular, I will focus on the demands of customizing or personalizing education to create "effective" workers in this new era. I strongly believe that in order to support such customization or provide on-demand education, we must understand both the structure of the educational content as well as its delivery through computer networks. In my research (with several of my doctoral students) at the Center for Information Systems Management at the University of Texas at Austin, we have found that both these features can be effectively addressed by the notion of structured multimedia documents and network-based publishing.

Let me briefly explain the imagery that courses through my mind when I mention these terms. I believe that multimedia has tremendous potential in extending the traditional education content from simple non-interactive paper-based documents to a world of interactive electronic documents. Electronic documents tend to range from text-only documents to more complex forms such as digital video plus soundtrack. We can take a step further with composite documents where several data types are integrated in a single document. Composite documents will allow, for instance, spreadsheet, word-processing and other multimedia objects belonging to different applications to be dragged and dropped into a single file. Each object knows what application is capable of manipulating it, or in the case of audio and video, viewing it. So, if the student wants to know the assumption in the formulas used in deriving data for a spreadsheet, clicking on the spreadsheet, sends a message to its parent a spreadsheet application, e.g., EXCEL on that machine to become active so that the user can view the formulas. This is a very powerful concept enabling complex forms of electronic documents. These forms of electronic documents combine computing (e.g., decision support tools, spreadsheet solvers, Operations Research models) with informative content that typically includes audio, video and images to create a more intuitive and user-friendly interface for educational content. What we have just described is pertinent for documents on a single machine, as well as documents spread out on a network of machines accessed by thousands of individuals.

Figure 1. EDUCATION BASED ON THE ELECTRONIC PUBLISHING ON THE INTERNET



The ability to "publish" electronic documents on computer networks so that students can interact with them is certain to become an essential ingredient of education in the 21st century. The past decade has seen a remarkable expansion in digital networks, especially the Internet, within the research and education community, from a state where networking was the purview of the technical wizards, to one where it is considered an essential tool by millions of researchers and educators. So, what exactly is this much talked about Internet? It is a network of networks, which, within the U.S., links one third of all two year and four year colleges and universities, many primary and secondary schools, public and private institutions, commercial enterprises, individuals in their homes, and foreign institutions in seventy countries. I use the term Internet to refer to general inter-networks–commercial (e.g. CompuServe, America On-Line, Prodigy, etc.), as well as government sponsored networks (e.g. NSFnet, CSnet, etc.), that interconnect academic, industrial, and government institutions. Since the mid-1980s with the advent of NSFnet, a high bandwidth backbone, the volume of traffic, the number of interconnected networks and the functionality of the Internet has grown by leaps and bounds, and continues to grow exponentially. Technically speaking, the Internet refers to the entire assemblage of linked networks using a common communications protocol (TCP/IP).

A new form of publishing, called network publishing, is taking place over the Internet. The definition of network publishing is the integration of computer networks and traditional publishing, such as print (e.g., newspapers, books, magazines), audio and video (e.g., movies, games) that facilitate organized information distribution and sharing and thereby creating a basis for a new educational experience. Technologies, such as World Wide Web and Gopher, are starting to emerge that will turn the Internet into the greatest publication environment and teaching tool seen to date. We can turn the Internet into a worldwide digital university in which students and educators can collaborate. As Figure 1 shows we can seamlessly create an environment where educational content providers – commercial publishers such as McGraw-Hill, database publishers, such as Mead Data Central's Lexis/Nexis database, and university faculty – can interact with different types of consumers, such as students working at home, in the organization or in the field. I will explain this vision in detail in Section 4.

The rest of this article is structured as follows. In Section 2, I will provide a brief overview of the history of IS to put into perspective where we have been and the lessons that we have learned. In Section 3, I will focus on the current state of IS education and highlight some of its strengths and deficiencies. In Section 4, I will present an introduction to the new developments in technology with which I am personally involved that I feel will have a profound impact on the different facets of education, its content, structure and delivery over the Internet.

2. A BRIEF HISTORY OF INFORMATION SYSTEMS

In the early days of IS, the profession was dominated by business languages popular on the IBM 370 mainframe such as COBOL and PL/1. Batch processing and a rigid centralized infrastructure were stressed. The large physical size of computers as well as their unique applications demanded such an environment. The typical academic IS department naturally reflected this orientation in both its teaching and its research. During this time, the Information Systems profession was seen as being incubated in the halls of the Computer Science department. However, with the increasing theoretical orientation of computer science, students who pondered the use of computers in the business realm were ignominiously requested to join the business school. So, MIS became the first applied computer science field to emerge.

How did my involvement with IS education begin? In the early 1970s, while a professor at Purdue University's Krannert School, I discussed some ideas about the role of computing in organizations with the dean, at that time, John Day. From these discussions our Management Information Systems (MIS) program was created. My first action was to hire Jay Nunamaker who was finishing his PhD at Case Western Reserve University. Together, we slowly built a program. I am happy to state that many of my doctoral students in those early years are now leaders in the IS field. Jim Cash is a chaired professor in the Harvard Business school. Ben Konsynski is a chaired professor at Emory. Clyde Holsapple is a chaired professor at the University of Kentucky. Robert Bonczek was starting on a promising future in the field when he passed away.

Because IS is driven by changes in technology, workers and managers in the trenches must always keep abreast of these changes. The IS researchers are no exception. However, waiting until technology emerges from the classrooms and laboratories of the other academic disciplines can leave one years behind the technology curve. Also, never leaving the business school building is crippling to a researcher. In order to obtain "state-of-art" knowledge, IS researchers must collaborate with their business school compatriots down the hall such as the Marketing and Operations Research departments. I see opportunities all across the campus coming from the economics, computer science, electrical engineering, psychology, RTF (radio, television and film), sociology, and library science buildings to list only a few of the more ripe possibilities. Over the years, I have had very successful research collaborations outside of IS which include work with Andy Bailey (President of the American Accounting Association), Vijay Mahajan (editor of the Journal of Marketing Research), Shimon Nof of Industrial Engineering, Aimo Hinkannen of Mathematics, Dan Marinescu of Computer Science and K.S. Fu of Electrical Engineering. These collaborations stemmed from the realization that IS cannot stand on its own, isolated from the rest of business, but must become a facilitator of cross-functional integration of other business functions.

Enough about myself. Let's get back on track and talk about IS. The 1970s were very exciting times. Just as computer science struggled to keep up with the vicious pace of change, the IS field has been forced to adopt similar changes into its fold. The torrid pace of innovation in the research institutions was amazing and forced us to rethink our curriculum. A major change took place in the late '70s when microcomputers were introduced. In addition to COBOL and PL/1, students now learned CP/M and Wordstar. Soon, MS-DOS, Lotus 1-2-3, dBase II, and Pascal were the subject of IS courses.

As mainframe databases grew in popularity, we introduced INGRES and DB/2 to the curriculum. This was later followed by more sophisticated relational databases, namely Oracle and Sybase. Again, in the late '80s there was a major shift in computing emphasis from packages to tool-sets for building enterprise computing systems. Computer networks were being widely installed and there was (and still is) a severe shortage of students skilled in managing and implementing Local Area Networks and Enterprise-Wide networks. Also, UNIX and C/C++ are becoming dominant tools, the knowledge of which is essential to understand and work with high-level client/server tools such as PowerBuilder.

The advances in communications and networking technology have been dramatic over the last ten years. In just the past three years, the following have occurred:

- Computer networks have become affordable and widely implemented;
- Cellular telephones and mobile computing have become ubiquitous;
- Distributed client-server computing has largely replaced centralized mainframe computing as the dominant model for organizational computing;
- The Internet backbone has been upgraded from 1.5 to 45 Mb/s links; according to the Internet Society, Internet now reaches 1,000,000 host computers in 70 countries and is growing at a rate of 11% per month.

Our vision of the future network remains that of a fiber optic backbone with access via fiber, copper, and radio. However, scenarios that were merely dreams three years ago have been developed to the point of wide acceptance. For example:

- The National Research and Education Network (NREN) will allow computers and terminals to be interconnected via links with gigabit (one billion b/s) data rates;
- Personal Communications Systems/Networks (PCS/PCN) will give individuals continuous untethered voice, data, and image access to the global public network and to the NREN via small wireless communicators;
- Television, personal computers, workstations, and facsimile will evolve into multimedia devices interconnected with other systems, data bases and entertainment services worldwide.

Parallel to technology, information management in companies has also evolved over the years. In most firms, the IS organizational environment was substantially constrained by technology. A mainframe computing environment like the 370 supported the main corporate wide accounting and personnel systems, while the isolated microcomputers supported a variety of planning, decision support and local database applications. Microcomputer networks introduced major changes to the corporate computing world and sent IS managers into raging fits. The inexpensive microcomputers and networking equipment made it easier for managers to run and manage their own departmental network rather than use the corporate mainframe. The corporate mainframe environment restricted individual access and depersonalized users, something managers despise when they are the victims. On the other hand, centralized management of the corporate computing resource made sense in terms of efficiency and administration, at least from the point of view of upper management.

From the above discussion, it is obvious that the emphasis on different topics has changed over the years. In particular, the subject matter that needs to be covered has changed tremendously over the last five years resulting in an educational crisis. The dilemma for the educator is two fold: first, understanding what the relevant subject material is in a rapidly evolving technological environment, and second, finding the right balance between depth and breadth that should be covered in a 14-week semester. The first issue is not as simple as it appears. Most subject matter is interlinked, and teaching one without the proper prerequisites or fundamentals, can cause turmoil in the classroom. This forces us to rethink the very fundamentals of IS education and raises the pertinent question: What exactly are the fundamental topics? Is our present curriculum so out-of-touch that we need major surgery or would a simple bandage do? In my opinion, we need to re-engineer the curriculum to keep in touch with the technological changes. Simple-minded patches to existing courses is not enough, as these only address the symptoms and not the root causes. If we don't find and solve the root-causes, we are bound to create more chaos and more problems will resurface later.

3. A FRAMEWORK FOR INTERNET-BASED EDUCATION

From earlier discussion, it is obvious that the evolution of technology and other changes in the business environment have had a significant impact on IS education. It would be judicious to recognize that education today and IS education, in particular, has three distinct dimensions (see Figure 2).

On one dimension, we have the diversity of subject content. In other words, what are the set of subjects and topics in each subject that should be taught? This is a dimension with which we deal at the beginning of every semester, as we take stock of the previous year's advances. Delineating the boundaries around subjects or, for that matter, topics is not an easy task, as mentioned earlier.

On another level, we have the types of interaction possible in the educational process. These basically consist of two broad types of faculty-student interactions:

- synchronous, face-to-face instructor - student interaction, either classroom-based (traditional) or distance-based via tele-conferencing; and
- asynchronous interaction between faculty and students via e-mail, bulletin boards and electronic publishing (e.g., CD-ROM, Gopher, World Wide Web).

Collaborative education tends to have both aspects of interactivity. For instance, a desktop video conference is a synchronous activity. On the other hand, interaction through groupware tools like Lotus Notes represents asynchronous interaction. On the Internet, the tools for support collaboration are improving rapidly. For instance, bulletin boards which are global in scope, e.g., USENET, for asynchronous interaction are widely available. Video conferencing can be done easily using MBone, the Multicast Backbone. MBone is a protocol that controls how information is sent in real-time to a variety of destinations on the Internet. Individual users on the Internet may 'subscribe' to an MBONE broadcast and thereby receive the information. Since MBONE is able to send a large amount of information very quickly, it is possible to send live digital video images worldwide. This capability opens up a huge new opportunity for wide-area synchronous education. For instance, students from Mexico, Australia, Burundi, India, and Belgium can all participate in a Sociology 101 lecture presented by a professor at the University of Italy. Collaborative education on the Internet presents an interesting perspective of the educational process that has not yet been explored.

Figure 2. DIMENSIONS OF EDUCATION

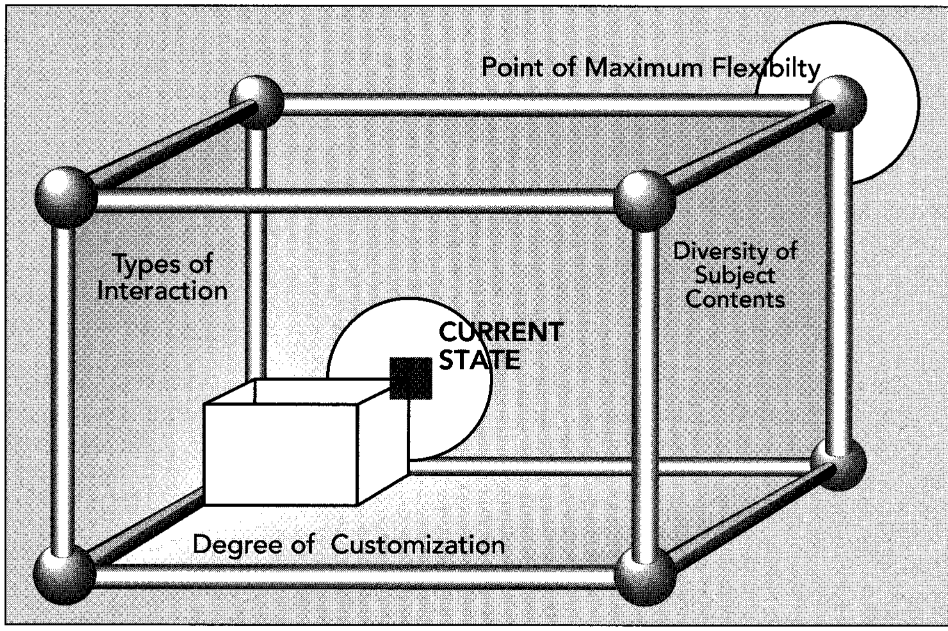
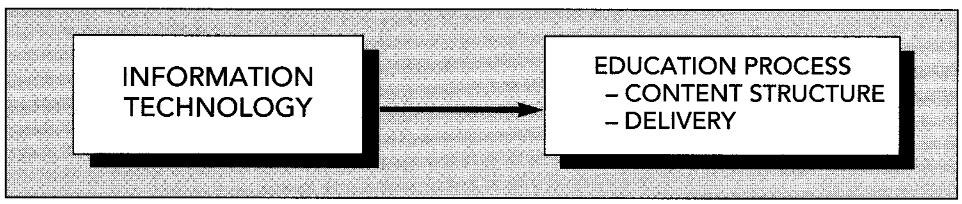


Figure 3. MODEL FOR TECHNOLOGY-PROCESS RESEARCH



On the third dimension, we have the degree of customization or personalization of both the content and the process. This is extremely important for on-the-job training, where users who have ever-changing educational needs are able to retrieve information where and when they need it. This form of on-demand education represents a radically new development, the requirements of which have not been addressed either by research or practice. One limited form of this type of on-demand education is the concept of correspondence courses popularized by Open University in England and universities in other Commonwealth countries. In this form of distance education, students interact or collaborate with the instructors via electronic mail or regular postal system. This form of education was found to have many problems: learner isolation, lack of motivation resulting in loss of interest and student-teacher interaction delay resulting in reduced learning effectiveness.

Now, let us examine the type of educational process employed in teaching. The study of relationships between types of information technology and the nature of the education process content or process structure is still in its infancy. A basic model for this type of research is presented in Figure 3.

At this point, it may be useful to make several observations. First, we haven't really changed the way we teach although we have changed the course material. In other words, we have not been able to use the technology to teach the technology. The technology part of the courseware is usually relegated to special laboratories where students can do software exercises after a lecture. Why do students have to schedule a special time to go to a room full of other cursing students and hand some sour overseer or lab assistant at the front door (which must be locked at all times) their ID card just to use a computer? It is no wonder that people fear technology. No integration between technology and teaching takes place. Students are taught to see technology as being separate from day to day work.

The rapidly falling price of microcomputers coupled with the increasing connectivity between them has slowly changed this impression in recent years. But, this problem still remains. In order to solve it, a way must be found to truly integrate technology with teaching. The average university classroom is little different than it was a century ago. Students sit in wooden chairs while a professor paces around the front of the room scribbling words on a board using a crumbly piece of chalk. Occasionally, some eager assistant professor may make transparencies and then spend half the classtime time adjusting the focus so that all six feet of screen can be legibly filled. Clearly, though, technology has made little impact on the art of teaching. For an academic discipline that teaches students how to effectively use and manage technology, this is truly embarrassing.

Computing technology has an extraordinary potential to reengineer business education. However, I contend that we have used technology to merely support and enhance existing educational processes. Even with the enormous advances in telecommunications enabling pervasive electronic interaction we still limit education to a physical classroom. The challenge, as it is in industry, is to redefine the educational processes to best exploit developments in technology.

Let's consider, informally, some of the factors that are an impetus to becoming serious about reengineering. First there is an increasingly enormous amount of knowledge that needs to be taught which is growing at an increasing rate. A good deal of the new information makes earlier information obsolete. In the information systems job-market, employers are interested in students who are trained in the new concepts and tools. This is reflected in the fact that we are no longer concerned with teaching business students who will become assembly language programmers, DBMS systems such as INGRES, or even old operating systems such as DOS, when WINDOWS 4.0 comes to market.

In the new learning environment, educational material will become personalized to the learner. Thus, the creation of cost effective personalized learning tools, is a challenge to be jointly overcome by IS professionals and education specialists. Another new feature to consider is the potential to allow collaboration among students in the learning process. Collaborative learning mirrors team based activities and thus prepares students for that type of organizational environment.

The above challenges are summarized as follows:

1. We need to develop learning material that can be easily updated and configured for the particular needs of students.
2. We must be capable of delivering education on demand any time and any place. This shifts educational delivery to the workplace, augmenting traditional educational centers.
3. We must emphasize collaborative education.

3.1 THE FUTURE EDUCATIONAL PROCESS

What does the future hold for education? The success of any venture depends upon how well we can adapt to changes. As educators, we all struggle with these changes, trying to adapt our curriculum to meet these challenges. As educators, we want to teach our students what they need to know. However, at the same time, we are conservative in that we try to avoid teaching what may be fashionable for only a short time. So, in many instances, there is a lag between changes in the environment and our response. The rapid advances brought on by the microcomputer revolution have been very slowly accepted by the educational community. We must realize that these changes in computing and communications are here to stay. There have been some very interesting and successful projects that integrate these technologies into teaching. The effective integration of technology into education is not measured by how well technology is taught, rather, it is measured by how well technology is used to teach.

Any future education process must involve the Internet. I strongly believe that Internet and its surrounding concepts will make the same impact on computing as did the personal computer in the early 1980s. Information sources accessed via the Internet form the ingredients of a digital library. Today, the network connects some information sources that are a mixture of publicly available (with or without charge) information and private information shared by collaborators. They include reference volumes, books, journals, newspapers, national phone directories, sound and voice recordings, images, video clips, scientific data (raw data streams from instruments and processed information), and private information services such as stock market reports and private newsletters. These information sources, when connected electronically through a network, represent important components of an emerging, universally accessible, digital library which would be the foundation for future educational processes.

The federal government has announced plans for the construction of the National Information Infrastructure (NII). This is similar to the Internet in that it allows people to connect with each other from all over the country. The government has some definite plans as to the type of services that the NII will provide. One group of services will be dedicated to enabling and improving education for both students and professionals. In one of their vision papers [1], they bring up the example of Big Sky Telegraph in Montana that connects 114 one-room schools together with Western Montana College. This connection allows students from rural Montana to communicate with students around the world. Not only are these students presented with a unique experience, they are actually using this connection to further their education. Another paper from CSPP [2] describes some additional possibilities for the use of the NII in education. I found one statement to be particularly interesting:

"Effective deployment of a computing and communications infrastructure for education and lifelong learning requires well trained and technologically experienced teachers and administrators who can facilitate the use, installation, and management of new instructional technologies such as digital interactive video, local area networks, and gateways to national networks."

They mention electronic libraries that people could use for, among other things, researching topics, viewing works of art, and learning new professional activities. However, from an implementation angle, it is not clear how to create and deploy educational content on the Internet. Basic research is required to identify mechanisms and methodologies that would be effective for this purpose. The next section will provide an overview of the research issues in accomplishing and supporting the next generation of IS education.

4. IMPLEMENTING THE VISION

At the University of Texas at Austin, our Center for Information Systems Management (CISM) is working with several different technologies in order to determine how they could best be used in the education process. We are also working with several major corporations to create an environment for implementing and testing the ideas pertinent to our vision. Our goal is to examine three facets of the education process:

- Content Development: How do we create educational content in the form of multimedia documents ? How do we structure these documents for maximum customization ?
- Content Delivery: How do we make information in electronic documents more mobile over the computer network? How do we structure information for mobility ?
- Content Interaction: How do we design collaborative and distance learning techniques that take advantage of the content as well as the delivery mechanisms ?

I will elaborate on each one of these in detail.

4.1 DEVELOPING EDUCATIONAL CONTENT

Developing content essentially involves the digitization of paper-based education products such as books, articles, tests, and the like for use on a computer. There are, however, several types of digitization that one must be aware of see Figure 4. Each type has certain advantages and disadvantages. I will discuss each one of these briefly and then indicate how they apply to content development in the educational setting.

DOCUMENT IMAGING

Document imaging emulates microfiche and microfilm. With an imaging system, a paper document can be passed through a scanner that renders it digital and store it as a bit-mapped image of the document. While scanning, keywords are entered for each document that help in indexing and retrieval.

The link between the traditional "pure" imaging system and a text file is OCR (optical character recognition). An OCR system consists of a scanner to image text and software that translates text into a computer-readable format. OCR systems do an excellent job producing computer-readable files from cleanly printed documents that are minimally formatted, such as legal contracts. But, highly formatted documents, such as a newsletter or a manufacturer's technical brief, resist easy processing. One reason for this is OCR programs cannot distinguish between two columns of text and a table with two columns. Your OCR operator has to decide which it is and instruct the program accordingly. Another problem with OCR is that it requires a good deal of manual checking and reworking to ensure that all the information in a document has been scanned into your computer properly.

The problem with the imaging approach is that the output contains only images, not encoded text. Consequently, searching for a particular text string inside images of documents is only possible using the keywords that were used to categorize documents. And without a specific, well-designed list of keywords, a large corpora of imaged documents would be created and could not be used effectively. This class of documents is characterized by little or no formal "internal" structure and provides limited freedom to use documents in a nonsequential manner. But, imaging systems do have their place. Large companies, such as insurance companies for claims processing, often use imaging systems for processing high volumes of routine yet critical documents, such as supplier invoices. The benefit of being able to retrieve paperwork instantly instead of waiting for days is obvious — time is money.

STRUCTURED DOCUMENTS

Usefulness of information (document content) is going to outlive the formats and computers that hold it today. The key to the future of electronic publishing lies in the ability to repackage information. This emphasizes the importance of viewing information as a raw resource which needs to be packaged or repackaged depending on the market needs and technology used for distribution. Document imaging does not facilitate this repackaging, so another solution is needed. This solution must address the challenge of customization, document interchange between heterogeneous or homogeneous computer systems and must also support the ability to take information and display or render it on different output media see Figure 5.

Structured documents provide the following capabilities which allow you to manipulate, edit and work with document content.

- The ability to format or render the document to suit different information delivery vehicles or output media. Figure 5 shows the different forms of formatting and

Figure 4. SPECTRUM OF DOCUMENT TYPES

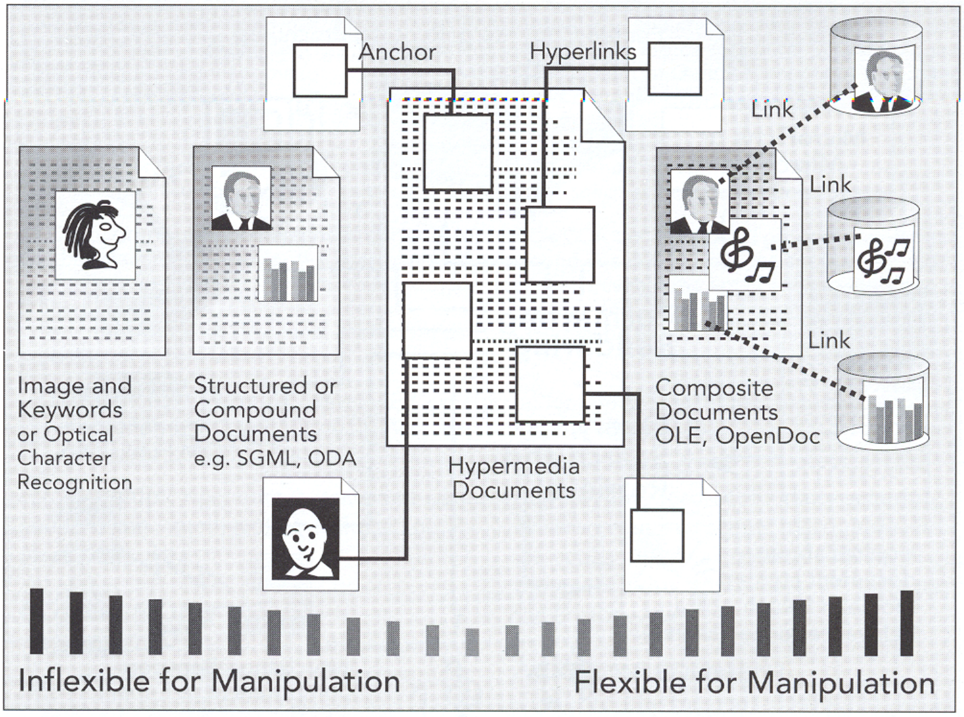
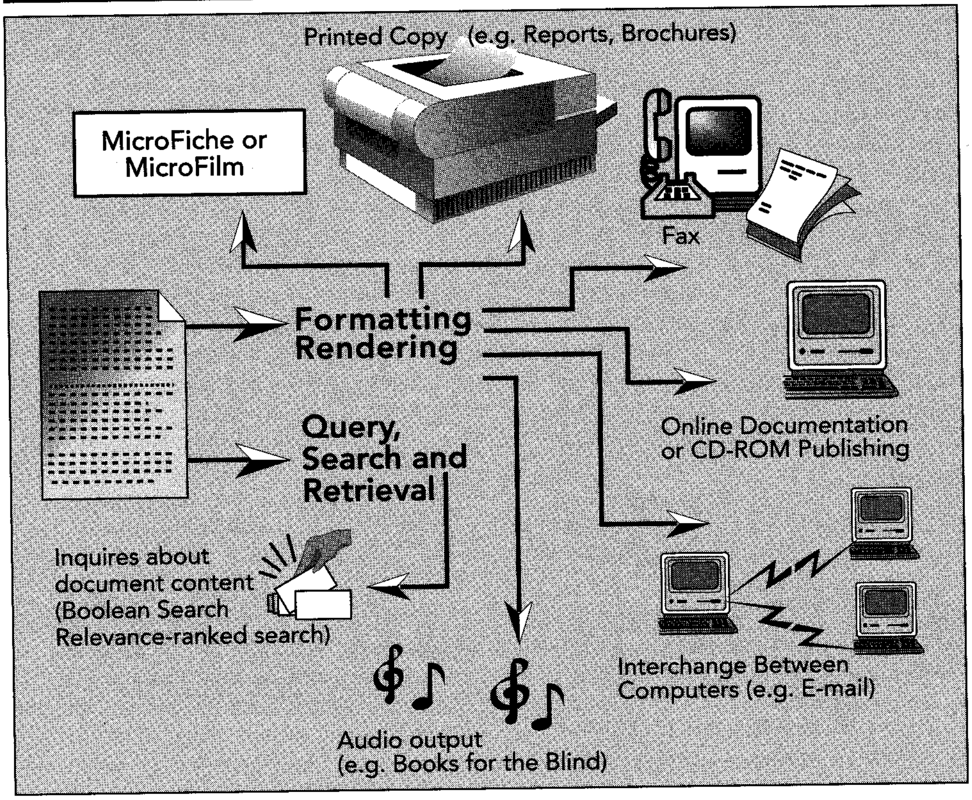


Figure 5. MULTI-FACETED RENDERING OF DOCUMENT CONTENT



rendering possible for a single document. In an educational setting, there could be several output media such as audio, Braille for the blind, computer screen or television. This variety of output media is a new phenomenon and requires tremendous flexibility on the part of the document format.

• The ability to create an editable document format. This breaks the mold of the static read-only documents and allows user interaction and manipulation, such as the ability to create bookmarks, highlight text, and write notes. In other words, documents are no longer stagnant, but can be edited, cross-referenced, and linked to other items, such as graphics, video, photo, or voice scripts. These features bring the document to a multi-user, networked platform with the ability to collaborate with other users on the document.

• The ability to query and search. Electronic documents can be easier to search and query than their hard-copy counterparts or image counterparts. Multiple-word (Boolean) and string searches are often used to locate and retrieve the information either as parts of the document or the entire document itself.

There is quite an array of standards and products to help create and manage documents electronically. What you choose depends on what you are trying to accomplish. If document interchange between platforms and fidelity to document format are your main concerns then you may choose a compound document architecture — DOA, RTF or CDA. See Table 1 below for a brief description of each.

If all three — editing, interchange and search and retrieval — are required, then the ISO Standard Generalized Markup Language (SGML) is the right architecture. SGML can "make text into a database," rendering it useful in the same way traditional databases are useful. SGML provides these capabilities through the concept of descriptive or generalized markup. The markup deals with the document content structure and its processing and is fairly new. It is far more flexible than document imaging and even compound documents, as its strength lies in the ability to make a separation between document content and structure, and document content and formatting. A detailed discussion of SGML is beyond the scope of this article.

4.2 DELIVERING EDUCATIONAL CONTENT

The value of information increases by enabling its mobility to areas where some entity individual or software program can make use of it. Hypermedia is a way of making document-based information more mobile. Relationships between documents can be represented through hypermedia links (hyperlinks) that allow the production of a complex, richly connected and cross-referenced body of knowledge. Mobility of information is necessary for the following reasons:

• Information or knowledge is seldom located on one node or server but is distributed throughout the network;

• Accessing and retrieving large monolithic documents is time consuming, and a good information management strategy is to split them up into smaller pieces to reduce user waiting and network utilization time. For users who spend time referencing very long documents, searching for information, and looking for interrelated documents, simple viewing / browsing, such as scrolling up and down pages, is certainly out of the question. Support for hypertext functionality, enabling cross-referencing and conditional branching to related parts of an electronic document is an essential requirement;

• Reuse of document fragments for composing new documents is more effective when information stored on individual systems and servers across an enterprise can be accessed from remote locations.

This structuring and navigation mechanism has been used effectively to deal with the presentation of large amounts of loosely structured information such as online documentation or computer-aided learning. New developments in the area of distributed hypermedia are illustrating the vast technological potential of a global digital library linking many document servers. However, mobility, high availability and scalability may well be the most difficult aspects of content publishing with regard to development and successful deployment. Mobility is, perhaps the most difficult of the three, due to factors such as media failure, machine failure and network partitioning or organization.

4.3 INTERACTION WITH ELECTRONIC DOCUMENTS

COLLABORATIVE LEARNING

The efficacy of interactive computer based training in acquiring new skills while maintaining student interest has already been widely accepted by school boards and corporations. Multimedia training systems allow students to proceed at their own pace, customize training programs, receive immediate self-testing and provide a host of other advantages over conventional teaching methods. Corporations have also found that it is a cost-effective way to train employees and maintain corporate-wide continuity in industries where high employee turnover has not justified personalized training in the past (examples are the hotel and airline hospitality businesses). One example of enhancing collaborative technology is video conferencing.

Video conferencing systems enable groups to see and hear each other. However, these systems are not geared to share on-line information such as spreadsheets, word processing documents, databases, scanned or moving images etc. Since much of today's information is on-line generated and stored on PCs and other desktop workstations–there is a disconnect between sharing e-mail messages and sharing documents such as spreadsheets. Recognizing this problem, several vendors of dedicated video conferencing equipment are incorporating data elements into their desktop systems, even though most of these systems today suffer from video compression bottlenecks and require relatively expensive, high-speed communications interfaces.

COMPOSITE DOCUMENTS

Composite documents represent what is known as document-oriented computing, are often confused in popular literature with compound and structured documents. We define the composite document as an interactive interface where all the documents, applications and data related to a particular task (for example, customer support or service), are assembled, arranged and interlinked in such a manner that the user can focus on the task at hand and be shielded from non-task related issues like access, data formats, location, computing or delivery mechanisms. Composite documents are especially powerful because they combine the notion of information composition with the distributed nature of information. Composite documents allow users to create interfaces that are dynamically constructed at execution time from other documents, data and computation objects that may be stored in the document libraries. These composite entities are not simply a static display of results from a query, but incorporate linkages to remote elements to build a structure. The composite document uses links to reference distributed, embedded composite objects/documents, instead of making a local copy of each entity. Linking enables virtual documents that are portable across multiple operating systems and GUIs and that can "intelligently" evaluate and act on network data.

Table 1. STANDARDS FOR DEFINING DOCUMENT CONTENT

SGML (Standard Generalized Markup Language): An ISO standard for interchange and multi-formatting description of text documents in terms of its logical structure. SGML's biggest and most powerful supporter has been the U.S. Department of Defense which has mandated SGML as the standard for electronic publishing in the Computer-aided Acquisition and Logistics Support (CALS) program.

ODA (Office Document Architecture): An ANSI and ISO standard for interchange of compound office documents. In contrast to SGML, ODA specifies both content and format.

CDA (Compound Document Architecture): DEC's CDA defines a set of ground rules content and format and services for the interchange of compound documents between applications. CDA-compliant applications can revise each other's documents even if the applications are written in different languages, run under different operating systems, and are located on the far corners of a distributed network. The most prominent use of CDA can be found in Lotus Notes the popular groupware software.

RTF (Rich-Text Format): Microsoft Corp. format for interchange of text between Microsoft products. RTF is also widely used by other text- processing applications.

CONCLUSIONS

As we can begin to see, education will change very dramatically. One definition that I tried to blur in this article was that of "the student". There will no longer be a distinction between school, home, and office. People will be students throughout their careers, both in school and on the job. Education will be as common as television. Who says they don't watch television? And, of those that do say that, how many are believed? The school schedule will disappear. Classes will always be offered 365 days a year, 24 hours a day. The student is the one who makes the decision of what he wants to study and when he wants to study it.

An important consideration is what the role of the educator will be in the virtual classroom of the future. As education is structured now, there are professors teaching the same "MIS 100: Introduction to MIS" in every university each semester sometimes using the same material. Why not reuse the content and consolidate the operations? In the virtual classroom of the future, there will be no distinction of location, and students should be able to take the class at MIT if they so choose and pass certain criteria.

A university of the future will bear more of a resemblance to today's television station than today's schools. Universities will act as clearing houses of education. Each university will become a digital library that publishes electronic documents and also digital video through one or more "channels" onto which it will "broadcast" a digital video feed of the daily schedule of classes given by various instructors. What we call today's instructors will be tomorrow's directors who will choreograph the learning "dance".

ACKNOWLEDGMENT

I would like to thank Ravi Kalakota and Stephen Whinston for several invigorating discussions of the visionary ideas presented in this article. I would also like to thank all my past and present students for making the past three decades an interesting and intellectually challenging phase of my career.

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ISSN 1055-3096