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ABSTRACT

The Institute for the Advancement of Emerging Technologies in Education (IAETE) at AEL recently explored the potential benefits and limitations of traditional print-based textbooks and many e-book alternatives. Having considered these media, IAETE created prototype interactive textbook pages that retain the salient aspects of print media while providing access to unlimited electronic resources. While the prototype appears to be a standard textbook, imperceptible digital watermarks embedded in the graphics act as convenient conduits to electronic access of dynamic content, assessments, applications, and communication tools. IAETE is exploring digital watermarking as an alternative to delivering electronic instructional media. This report covers the following topics: (1) traditional textbooks; (2) electronic books (e-books); (3) issues influencing e-book development; (4) alternatives for electronic publishing of textbooks, including handheld devices, customized printing, and Web-based delivery; (5) the interactive textbook; and usability study and group interview results. PowerPoint print-outs from a presentation on digital watermarking are attached. (Contains 21 references.) (MES)

Using Imperceptible Digital Watermarking Technologies to Transform Educational Media: A Prototype

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The Institute for the Advancement of Emerging Technologies in Education (IAETE) at AEL recently explored the potential benefits and limitations of traditional print-based textbooks and many e-book alternatives. Having considered these media, IAETE created prototype interactive textbook pages that retain the salient aspects of print media while providing access to unlimited electronic resources. While the prototype appears to be a standard textbook, imperceptible digital watermarks embedded in the graphics act as convenient conduits to electronic access of dynamic content, assessments, applications, and communication tools. IAETE is exploring digital watermarking as an alternative to delivering electronic instructional media.

Traditional Textbooks

Textbooks have long been the mainstay of instructional media in classrooms; however, much has been reported about the inadequacies of widely adopted print-based textbooks. In a review of 12 prominent physical sciences textbooks, nine reviewers (seven of whom are professors in physics departments in various institutions of higher education) determined that none of the books were adequate and most contained hundreds of errors (Hubisz, 2001).

Project 2061, the science, mathematics, and technology education reform initiative of the American Association for the Advancement of Science (AAAS), reported similar findings. A Project 2061 study examined how well middle-grade textbooks help students learn key ideas in earth science, life science, and physical science. Dr. Jo Ellen Roseman, who headed the study and now directs Project 2061, stated, "This study probed beyond the usual superficial alignment by topic heading. Instead, it examined the texts' quality of instruction, using criteria drawn from the best available research about how students learn" (Project 2061, 1999). The evaluation process was developed by scientists, mathematicians, educators, and curriculum developers, with funding from the National Science Foundation. Review teams included teachers, curriculum specialists, and professors of science education. The review found none of the widely used science textbooks for middle school to be satisfactory (Project 2061, 1999).

Another criticism of traditional print-based textbooks is that they quickly become outdated. Chris Jonson, social studies editor for McDougall Littell (a division of Houghton Mifflin), noted in a National Public Radio interview that production of print-based textbooks immediately stopped following the terrorist hijackings and attacks of September 11, 2001 (National Public Radio, 2001a). Textbook companies understood the importance of including in their textbooks the events of that day and the days that followed. Textbooks without such information are now outdated. Given the limitations of current print-based textbooks and the opportunities created by digital technologies, conditions appear to be favorable for the introduction of electronic alternatives to supplement, if not replace, traditional textbooks.

Electronic Books

Electronic books come in multiple formats, and the term *electronic book* is broadly defined in the industry. Some use *e-book* to refer to the electronic delivery of what was once presented as text printed on paper. The user reads text on a computer display, often a laptop computer or handheld device. Used this way, devices such as Compaq's iPAQ can be classified as e-books, though, like laptop or desktop computers, they are rarely used solely for this purpose.

Some people use the term *e-book* to refer to specialized electronic devices modeled after the familiar print-based book. These devices, ranging in price from $125 to $600, typically employ proprietary file formats and serve a single purpose.

Adherents of multipurpose, handheld computing devices, such as the Palm handheld or Compaq's iPAQ, think these will be the most prevalent e-books for classroom use. Others propose that software, such as Microsoft Reader or Adobe Acrobat, will form the basis of the most viable electronic book model. In short, promoters of electronic books take many approaches to the production and dissemination of information.

Issues Influencing E-book Development

Perhaps the lack of standardization—or even suitable parameters in e-book technology—and the absence of a clear leader in the market have contributed to a flurry of activity in the publishing industry. Many companies are trying to position themselves to set the standard for others to follow. Certainly standards have been implemented to provide a consistent basis for e-books such as goReader and similar products. The Open eBook Forum (OeBF) was developed by the Association of American Publishers with assistance from companies such as Microsoft and Adobe (http://www.openebook.org). At the core of the OeBF effort has been a concern for safeguarding intellectual property and protecting current economic models (Jensen, 2000). This concern has not necessarily impeded progress. Looney and Sheehan (2001) suggest that digital rights management of software and electronic commerce has been a catalyst for e-book interest.

Although considerable attention focuses on standards that may make e-books more attractive to both users and content creators, other concerns have emerged. For example, Nielsen (2000) suggests that users read approximately 25 percent slower from a computer screen than from a printed page. While handheld devices are proliferating in schools, they are being deployed without regard to such issues. This impact this might have on learners is clearly no small matter. According to Morehead (2001), Kathleen Brantley, director of product development at Market Data Retrieval, suggests that it is still very early to quantify the number of handheld devices currently in use in schools. Yet Palm reports that education is approximately eight percent of its business (Morehead, 2001). While the actual number of handheld devices currently in use in schools is difficult to determine, Zeitchik, Reid, and Nawotka (2001) estimate there are now more than 12 million personal digital assistants in circulation.

Another concern involves the fluidity of e-book content. For example, what appears to be a benefit in the wake of the events of September 11, 2001—the ability to customize content quickly—might also present problems. Gilbert Sewall, director of the American Textbook Council, notes that local pressures could influence how sensitive topics (e.g., evolution or the depiction of Columbus) are presented (Axelson & Hardy, 1999). Customization of content, then, could lead to vast curricular differences among schools, making student transfers, even between schools in the same district, more difficult.

Policy issues have also been raised. Textbooks are typically adopted for a predetermined number of years, and the fact that important events that should be included can and do occur soon after adoption is regrettable but understood. Conversely, one of the most attractive features of electronic books—their ability to be updated regularly and quickly—then creates additional work for personnel responsible for textbook adoption. Furthermore, new funding models (e.g., subscription-based services versus one-time purchases) must be taken into account. It appears that electronic textbooks could save schools money, as traditional text printing and storage costs are significant. However, this benefit may not be immediately apparent. According to Odlyzko (1999), publishers generally encounter additional costs—not savings—to produce electronic publications.

It is difficult to justify eradicating printed textbooks from the options available to schools. Despite inadequacies, McKnight, Dillon, and Richardson (1996) point out that, "We have had nearly 500 years experience of using printed textbooks, and they not only support a wide range of applications, but users also have such a strong mental model of their generic structure and organization that they can successfully adopt an equally wide range of usage strategies" (p. 631). They further suggest that while hypertext can support activities that would be difficult, if not impossible, to accomplish with printed text, we must be sure that these capabilities are used in pursuit of valid learning tasks: "It is not sufficient that we can browse a million pages on our desktop, or link 100 articles together for rapid retrieval at the click of a mouse button: such capabilities are only important in terms of their utility to

human learners. Yet there are few signs that most learning scenarios require such support, and little knowledge on how we might best provide it in terms of usability, even if it were required" (p. 631).

In Search of the Best Alternative

It is hard to predict what textbooks might look like in 5 to 10 years. During an interview, Preston Gralla, technology author and executive editor of ZDNet, proposed that education could be a niche market for electronic publishers, regardless of their success or failure in other areas (National Public Radio, 2001b). Indeed, major textbook companies are positioning themselves to take advantage of the surge in portable handheld devices in the education market. Strategies differ from company to company, but three approaches are most common: handheld devices, customized printing, and Web-based delivery.

Handheld Devices

Harcourt College Publishers is partnering with goReader to offer electronic college textbooks, a move that signals their support for the e-book platform (Writers Write, Inc., 2001). McGraw-Hill is partnering with Digital Owl to "mobilize and market digital information through targeted Web sites and handheld devices" (McGraw-Hill Companies, n.d.).

Customized Printing

Classwell Learning Group, in partnership with Kinko's, exemplifies a customized publishing approach. Teachers can access online tools and content supplied by Classwell to create customized workbooks for students. Once complete, the workbooks are electronically delivered to Kinko's, which prints, assembles, and delivers them (Classwell, 2001). Other customizable publishing efforts include McGraw-Hill's Primis Online, which provides access to more than 350,000 pages of content, as well as PowerWeb sites that draw on the Internet's power to provide current information (McGraw-Hill Primis Custom Publishing, n.d.).

Even as customized publishing makes it possible to provide content to meet the individual needs of learners, proposed legislation promises to make textbook content delivery more accessible for all learners. The proposed Instructional Materials Accessibility Act of 2002 would mandate that students who are visually impaired or otherwise impeded by print media have access to instructional materials, including textbooks, in formats they can use (American Foundation for the Blind, 2001). With the establishment of a national clearinghouse to receive, catalog, store, and disseminate electronic files from publishers, the benefits are potentially far-reaching.

Web-based Delivery

Much of the current activity around e-book development focuses on Web-based delivery of content, though approaches vary tremendously. Many of the major publishers, including McGraw-Hill, Pearson, Thomson, and John Wiley, have added multimedia and assessment supplements to their textbooks (Zeitchik, Reid, & Nawotka, 2001). McGraw-Hill's comprehensive approach provides e-text that mirrors the book's print edition and incorporates features such as audio and video clips. To complement this effort, the company has launched the McGraw-Hill Learning Network, offering a number of resources for educators, students, and parents (Trotter, 2001). Houghton Mifflin and netLibrary have launched a digital textbook initiative aimed at bringing Houghton Mifflin's College Division texts to a Web-based platform called MetaText ("Textbooks to Become Interactive," 2001).

The :CueCat bar code technology, another Web-based approach, is being used by Harcourt College Publishers in more than 80 college textbooks. A cat-shaped scanning device is used to swipe bar codes from the printed page and take the reader's computer to a specified Web site. Houghton Mifflin is also piloting the technology in some college-level textbooks ("Harcourt Embraces :CueCat Technology," 2001).

The Interactive Textbook: Combining Old and New

In designing next-generation textbooks, IAETE staff think it only practical to consider what McKnight, Dillon, and Richardson (1996) describe as our most successful information technology—the printed book. To

address the inherent limitations of print media, the application and implications of imperceptible digital watermarking technologies were considered in the context of learning environments. Prototype textbook pages were developed using Digimarc MediaBridge software and a widely used middle school science textbook.

The software creates an imperceptible digital watermark consisting of XML-based code embedded in a graphic or other media element. With the aid of an optical reader device, such as a digital camera connected to a computer, the software "reads" the watermark, activates a standard Web browser, and delivers the user to a specified Web site or application. The interactive textbook extends the functionality of print media so that applications now possible on the Web, including discussions with peers or experts, real-time data manipulation, and participation in simulations or virtual environments, are possible within the context of the interactive book.

Static information, such as the definition of a term, is presented in a common textbook format and organizational structure, but information likely to change, such as an assessment tool, is linked to the printed page with an imperceptible digital watermark. The digital watermark feature makes the content highly customizable. Unique identifiers embedded in each image enable a content manager to access or change the referent URL to provide a relevant and timely experience for the user without requiring any change to the printed book.

Embedding a watermark in an image is as easy as applying a filter in Photoshop. The process for transforming a printed textbook into an electronic textbook does not displace well-established textbook production methods and utilizes standard image processing software. It is already adopted by print media and could be easily integrated by the textbook publishing industry.

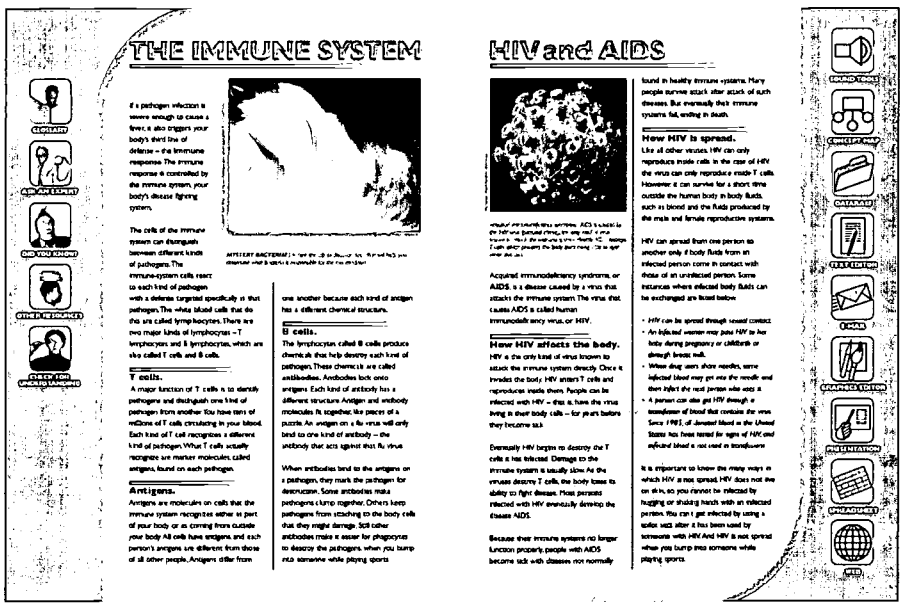

Figure 1. Prototype pages developed by IAETE at AEL

Prototype pages are presented in Figure 1. An imperceptible digital watermark is embedded in each graphic, delivering users to a specified Web site or application. The resource bar on the left contains five resource links:

1. *Glossary* links users to definitions of terms related to the subject content and can be chapter- or even page-specific.

2. *Ask an Expert* links users to experts who can answer student-generated questions. The expert could be identified by the textbook company or by the teacher, allowing international, national, local, or school-based authorities to share information.

3. *Did You Know* provides a connection to materials designed for differentiated instruction. Students who progress quickly through their work could explore many layers of supplemental content through this link. The activities could be high-interest and require varied skill levels.

4. *Other Resources* presents supplemental, content-related materials, information, and activities.

5. *Check for Understanding* offers opportunities to assess student comprehension through traditional assessments or problem-based assignments.

The tool bar on the right displays nine icons linked to different tools (i.e., Sound Tools, Concept Map, Database, Text Editor, E-mail, Graphics Editor, Presentation, Spreadsheet, and Web). Each icon provides a shortcut to a designated application, giving students instant access through the watermark in the textbook.

The illustrations on the page are also digitally watermarked and serve as a point of departure for activities related to the text. In Figure 1, the digital watermark in the "Mystery Bacteria?" (ear) illustration delivers students to an online virtual lab simulation where they attempt to identify the pictured bacteria. Other possibilities for links include labeled diagrams, enhancements of photographs or maps, and questions related to the illustration.

The adaptive nature of the technology holds promise for highly customizable content in multiple curricular areas. Differentiated instruction is supported by enabling students to "drill down" in content. Real-time, embedded assessments are supported, as is the ability to follow a student's path through the content. Sound tools, concept mapping, and other applications engage students and enable them to interact with the content in whatever way is most appropriate for them. Although the examples above were used in the prototype, different tools and resources could easily be used to support other content areas.

Usability Study and Group Interview

Following the development of the prototype, IAETE conducted a usability study, then a small group interview. Participants included middle school and high school science teachers. The usability study was conducted prior to the focus group to elicit unbiased results. The participants were given five assignments, without instruction, which required participants to access multiple resources and tools. They worked as a group, and a talk-aloud protocol was used. Following the usability study, the group discussed the prototype and identified five key benefits: (1) the availability of real-time information, (2) more efficient computer use, (3) accommodation of multiple modes of learning, (4) standards-based content, and (5) the availability of assistive resources. Four limitations were noted: (1) access to computing device, (2) cost, (3) durability, and (4) the need for additional workspace.

The teachers rated the interface design and the ease of operation of the interactive textbook using a five-point scale, where 1 was the most negative response and 5 was the most positive response. The mean response for interface design was 4.75, and the mean response for ease of operation was 3.5.

During group discussion, the tool bar was the subject of much debate. Some teachers thought it was unnecessary, while others argued that the shortcuts would be helpful for keeping students on task. The teachers brainstormed about the possible layout (e.g., putting the tool bar on the back cover) and potential functions (e.g., using the sound tool to assist ESL students). IAETE will use the results of this study to refine the prototype and prepare for a larger usability study that will include teachers and students.

Summary

At present, e-books appear to be supplementing print media, not replacing them (Ditlea, 2000). This suggests that print-based textbooks are likely to be prevalent in classrooms for some time. This prototype concept, using imperceptible digital watermark technology, demonstrates a realistic and practical method for linking print and digital media. It is likely that the limitations identified through the usability study and focused group interview can easily be addressed as handheld computing devices become more commonplace in classrooms and more suitable optical reader devices become available.

Imagine it—a smaller textbook accompanied by a small, wireless, tablet-like computer and reader device/stylus that is no bigger than a permanent marker. The interactive textbook is a viable model affording students the best aspects of print and electronic media.

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AECT ★ November 14, 2002

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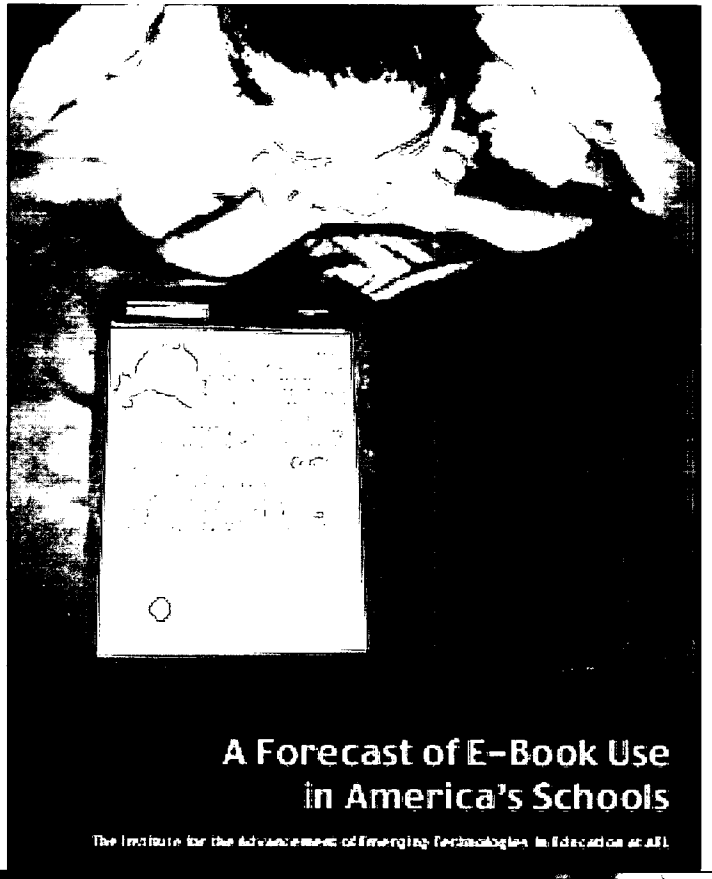
Textbooks

- The dominant form of instructional media
- Development is driven by market demand
- Content can become outdated quickly
- Often criticized for being ill-suited to curriculum and assessments
- Plagued with errors (Hubisz, 2001; Roseman, Kesidou, Stern, & Caldwell, 1999)

A Forecast of E-Book Use in America's Schools

- Survey of textbook adoption staff
  - 22 States & 100 largest school districts
- Highlights
  - Selection policies
  - Frequency of adoption
  - Satisfaction
  - E-book possibilities



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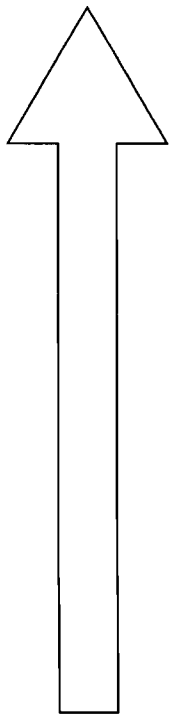
What is an E-Book?

- **E-book**: small electronic device on which e-text may be loaded
- **E-text**: written material delivered digitally on e-book or computer
- **E-textbook**: electronic media pre-selected for instruction and displayed on e-book

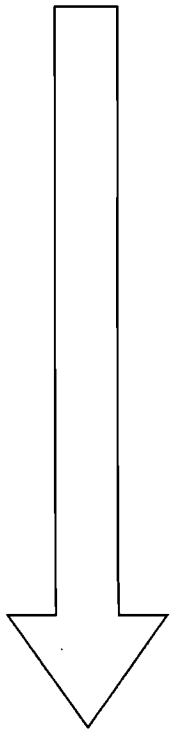
Most Important Selection Priorities



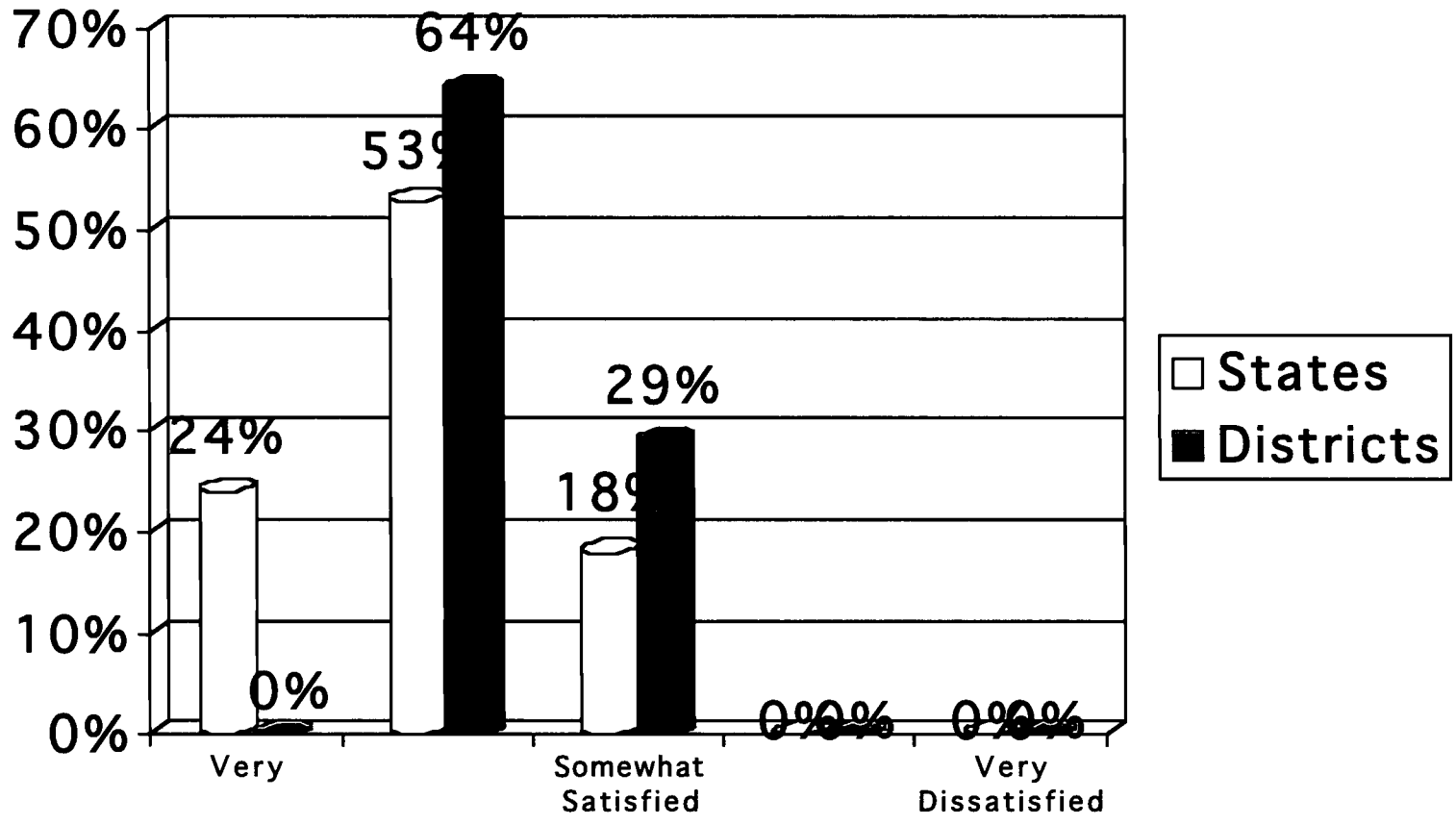
STATES	DISTRICTS
Match standards	Match standards
Accuracy	Accuracy
Currency	Currency
Recommended activities	Organization
Organization	Recommended activities

Least Important Selection Priorities

STATES	DISTRICTS
Cost	Cost
Supplemental electronic media	Supplemental electronic media
Visual presentation	Publishing company
Publishing company	Visual presentation
Noted authors	Noted authors



Satisfaction



Perceived Strengths of Current Textbooks

States

- Accuracy (94%)
- Match standards & assessments (82%)
- Currency of information (76%)

Districts

- Match standards & assessments (71%)
- Meet students' needs (64%)

Perceived Weakness of Current Textbooks

States	Districts
• Too heavy to carry (77%)	• Too heavy to carry (71%) • Outdated (50%)

Current Practices

- Adoption cycles: 4 to 7 years
- The most common procedure for adopting textbooks is allowing districts to select from a state-approved list.
- None of the states responding requires districts to adopt a print-based textbook.

Current Practices

- Science and reading are the most difficult areas in which to find appropriate textbook selections.
- There was little agreement about the instructional level for which it is most difficult to make appropriate book selections.
- Respondents indicated that print-based textbooks are important or very important in their instructional programs.

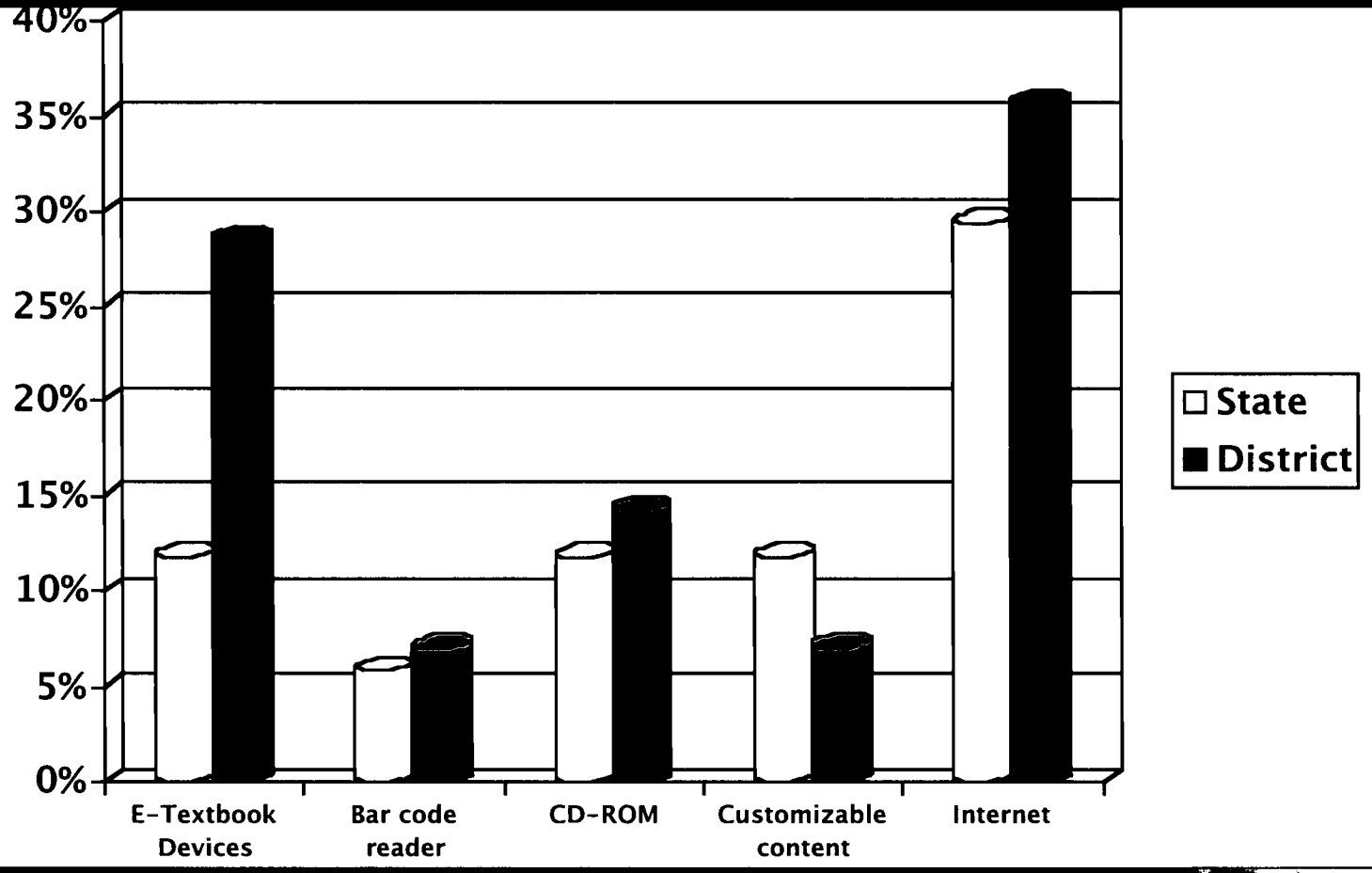
Perceived Benefits and Barriers of Electronic Media

- **Greatest benefit:** Information remains current
  - Greater control over content
- **Greatest barrier:** Access for all students

The Internet is perceived to be most likely choice of electronic media delivery

There is little interest in using e-books

Predicting Electronic Devices



The Web as a Textbook Replacement

- Individuals read 25% more slowly from a screen (Nielson, 2000)
- Novice users are often impeded by cumbersome interface
- Information overload

Is It Time to Abandon the Textbook?

"We have had 500 years experience using printed textbooks and they not only support a wide range of applications, but users also have such a strong mental model of their generic structure and organization that they can successfully adopt an equally wide range of usage strategies."

(McKnight, Dillon, and Richardson, 1996)

be

instantly

respond to requests for more information

What if Textbooks could...

change

the way students and teachers use the Internet

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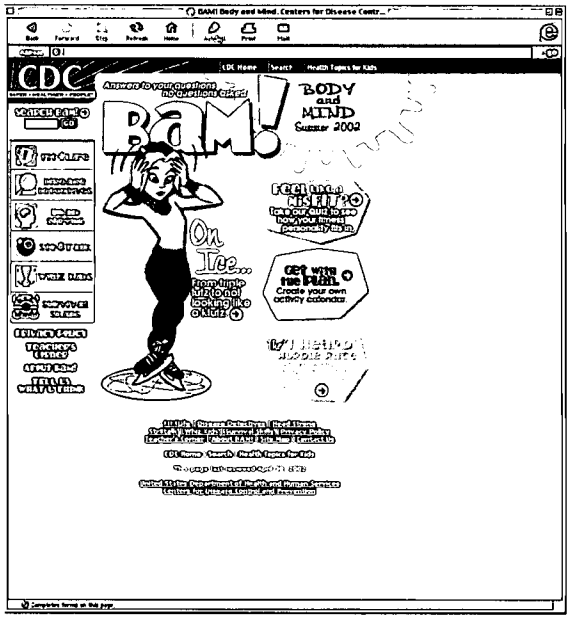
Digital Watermarking

- Digital code in printed material
- Inconspicuous to readers
- "Readable" by consumer PC cameras and scanners
- Instantly sends readers to specified Internet destination
- Turns every printed item into a direct Internet portal
- Can instantly launch applications from a hard drive

Connecting Print to the Web



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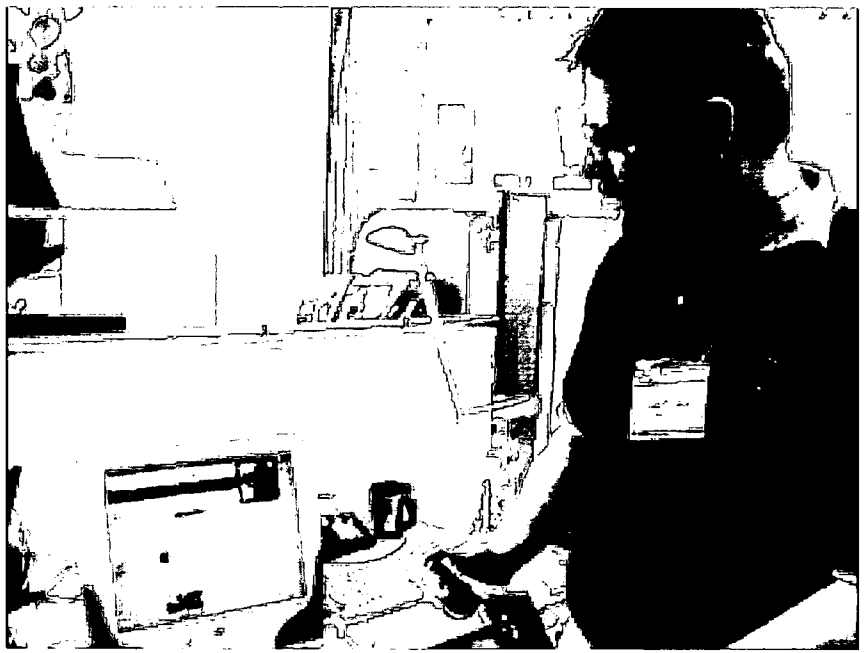

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THE IMMUNE SYSTEM

MYSTERY BACTERIA? *Explore the lab to discover clues that will help you determine what bacteria is responsible for the this condition.*

If a pathogen infection is severe enough to cause a fever, it also triggers your body's third line of defense – the **immune response.** The immune response is controlled by the immune system, your body's disease fighting system.

The cells of the immune system can distinguish between different kinds of pathogens. The immune-system cells react to each kind of pathogen with a defense targeted specifically at that pathogen. The white blood cells that do this are called **lymphocytes.** There are two major kinds of lymphocytes – T lymphocytes and B lymphocytes, which are also called T cells and B cells.

T cells.

A major function of **T cells** is to identify pathogens and distinguish one kind of pathogen from another. You have tens of millions of T cells circulating in your blood. Each kind of T cell recognizes a different kind of pathogen. What T cells actually recognize are marker molecules, called antigens, found on each pathogen.

Antigens.

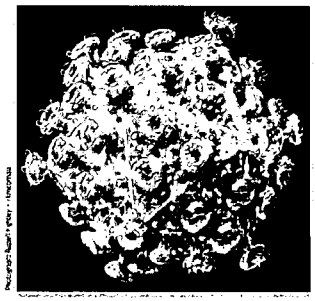
Antigens are molecules on cells that the immune system recognizes either as part of your body or as coming from outside your body. All cells have antigens, and each person's antigens are different from those of all other people. Antigens differ from one another because each kind of antigen has a different chemical structure.

B cells.

The lymphocytes called **B cells** produce chemicals that help destroy each kind of pathogen. These chemicals are called **antibodies.** Antibodies lock onto antigens. Each kind of antibody has a different structure. Antigen and antibody molecules fit together, like pieces of a puzzle. An antigen on a flu virus will only bind to one kind of antibody – the antibody that acts against that flu virus.

When antibodies bind to the antigens on a pathogen, they mark the pathogen for destruction. Some antibodies make pathogens clump together. Others keep pathogens from attaching to the body cells that they might damage. Still other antibodies make it easier for phagocytes to destroy the pathogens. when you bump into someone while playing sports.

HIV and AIDS



Acquired immunodeficiency syndrome. AIDS is caused by the HIV virus (pictured above), the only kind of virus known to attack the immune system directly. AIDS destroys T cells, which prevents the body from being able to fight other diseases.

Acquired immunodeficiency syndrome, or **AIDS**, is a disease caused by a virus that attacks the immune system. The virus that causes AIDS is called human immunodeficiency virus, or **HIV**.

How HIV affects the body.

HIV is the only kind of virus known to attack the immune system directly. Once it invades the body, HIV enters T cells and reproduces inside them. People can be infected with HIV – that is, have the virus living in their body cells – for years before they become sick.

Eventually HIV begins to destroy the T cells it has infected. Damage to the immune system is usually slow. As the viruses destroy T cells, the body loses its ability to fight disease. Most persons infected with HIV eventually develop the disease AIDS.

Because their immune systems no longer function properly, people with AIDS become sick with diseases not normally found in healthy immune systems. Many people survive attack after attack of such diseases. But eventually their immune systems fail, ending in death.

How HIV is spread.

Like all other viruses, HIV can only reproduce inside cells. In the case of HIV, the virus can only reproduce inside T cells. However, it can survive for a short time outside the human body in body fluids, such as blood and the fluids produced by the male and female reproductive systems.

HIV can spread from one person to another only if body fluids from an infected person come in contact with those of an uninfected person. Some instances where infected body fluids can be exchanged are listed below.

- *HIV can be spread through sexual contact.*
- *An infected woman may pass HIV to her baby during pregnancy or childbirth or through breast milk.*
- *When drug users share needles, some infected blood may get into the needle and then infect the next person who uses it.*
- *A person can also get HIV through a transfusion of blood that contains the virus. Since 1985, all donated blood in the United States has been tested for signs of HIV, and infected blood is not used in transfusions.*

It is important to know the many ways in which HIV is not spread. HIV does not live on skin, so you cannot be infected by hugging or shaking hands with an infected person. You can't get infected by using a toilet seat after it has been used by someone with HIV. And HIV is not spread when you bump into someone while playing sports.

Interactive Textbook

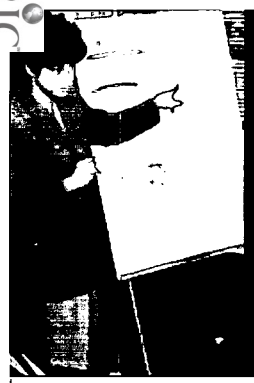
- Capitalizes on well-established textbook production methods
- Retains the most salient aspects of print media while providing instant and convenient access to
  - dynamic content
  - assessments
  - applications
  - communications tools
- Images do not differ in appearance from those found in traditional printed textbooks

Focus Group Interview and Usability Study

- Talk aloud method
- Middle and high school science teachers
- Appeal of the interface (75% “excellent”; 25% “good”)
- Ease of operation (75% “fair”; 25% “excellent”)
- Real-time information a key benefit
- Computer access issues a key concern

Next Steps

- Develop or identify enhanced reader device
- Develop assessment and reporting components



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