A Digital Learning Space for Science, Mathematics, Engineering and Technology Education

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NEEDS Project Director
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Outline

- Introduction
- Synthesis Coalition
- NEEDS—The National Engineering Education Delivery System
- Towards a Digital Learning Space for Science Mathematics Engineering and Technology Education
- Prototype: www.smete.org

Copies of this presentation will be available at: http://www.smete.org/smete/info/presentations/

- Reform undergraduate engineering curricula
- Improve retention
- Link to K-14
- Develop digital infrastructure ➔ NEEDS
Synthesis Coalition Strategy

• Introduce multidisciplinary systems design
  – Mechatronics
  – Architecture/Engineering/Construction
• Bring industry and research into the classroom
• Enhance laboratory/hands-on learning
• Increase social context of technology
• Improve student’s communication and teaming skills
• Introduce new delivery/learning styles
Multidisciplinary, Multimedia Case Studies

- Highlight examples of successfully engineered design products.
- Brings “best practices” from industry into the classroom:
  - customer-driven design
  - quality and continuous improvement
  - multifunctional teams
  - design for ‘x’ (assembly, environment, service, etc.)
- Complements dissection and design activities.
- Promotes integrative thinking.
Multidisciplinary Mechatronic Cases and Dissection Exercises

Some of the Disciplines Involved:

- Mechanical Engineering
- Electrical Engineering
- Computer Engineering
- User Interface Designers
- Manufacturing Engineering
- Industrial/Process Engineering
- Business and Management of Technology
Multimedia Cases & Mechanical Dissection
Promote Integrative Learning

Abstract  Theory &
Conceptualization

Concrete Experiences

Active Experimentation

Reflection

Abstract  Theory &
Conceptualization

Virtual Disk Drive Case Study
Integrates multimedia case, dissection
and design activities
Synthesis Courseware Integrates Research, Education and Industry

**Technical Research**
Disk Drive
High Speed Networks
Multimedia & Video Servers
Design & Mfg. Integration

**Industry**
Western Digital
IBM Almaden Research
Berkeley Computer Mechanics Lab

**Education Research**
peer, scaffolded & experiential learning

Virtual Disk Drive Case Study - Game, Dissection Example
THE VIRTUAL
DISK DRIVE DESIGN STUDIO
voice coil motor

spindle motor

disk platter

head stack assembly

printed circuit board

click on one of these disk drive components
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• Reform engineering education curricula
• Develop digital infrastructure ← NEEDS
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NEEDS—The National Engineering Education Delivery System
www.needs.org
We are building upon our experience with NEEDS as the foundation for the SMETE Information Portal, coupled with on-going research.
How does NEEDS help users “re-use” learning materials?

• Provides mechanisms to help user locate materials
  – Uses standardized descriptions (metadata) to describe resources

• Provides mechanisms to help users evaluate the “quality of materials”

• Developed upon an extendable platform to support multiple uses, as well as integrate new services and features
Goals (1998–2001)

• Provide a service to the engineering education community
• Grow and evolve NEEDS as the foundation for an on-line engineering education community
• Expand courseware review and evaluation efforts
• Serve as a bridge to the development of a National SMETE Digital Library
What Is NEEDS?

• Integrated Database of Multimedia Engineering Courseware
  – Bibliographic records with downloadable courseware
  – Multimedia elements - downloadable movies, images, and text

• Multilevel Courseware Evaluation System
  – Peer Review of Courseware
  – *Premier Award for Excellence in Engineering Education Courseware*

• Expanding Services and Features
**Example Record:**

**www.needs.org**

<table>
<thead>
<tr>
<th>The Virtual Disk Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Premier Courseware of 1997</strong></td>
</tr>
<tr>
<td><strong>Title:</strong> The Virtual Disk Drive Design Studio</td>
</tr>
<tr>
<td><strong>Authors:</strong> David Y. Yu, Alice M. Agogino</td>
</tr>
<tr>
<td><strong>Publisher:</strong> University of California at Berkeley (03/1997)</td>
</tr>
<tr>
<td><strong>Courseware Series:</strong> Multimedia Case Studies of Design in Industry</td>
</tr>
<tr>
<td><strong>Version:</strong> 1.0b5</td>
</tr>
</tbody>
</table>
| **Summary:** The Multimedia Virtual Disk Drive Design Studio is an engineering design case study using interactive multimedia courseware for undergraduate engineering and science students. The purpose of this multimedia case is to introduce students to the world of mechatronics in the form of a disk drive. Students play the role of a project engineer for the ACME disk drive company and will have to mine out the necessary information from a multimedia archive in order to build a new disk drive model. Students will have to keep track of the development and production costs. They will also be asked to launch their new disk drives in a certain time frame, simulating the idea of time-to-market. This interactive disk drive case study is ideally complemented by hands-on mechanical dissection of an actual disk drive.

This entire project is put together using Macromedia Director. This cross-platform software will allow us to distribute CD-ROMs to a wide spectrum of students around the country with 2x CD-ROM drives. The author is currently collaborating with Western Digital Corporation and IBM Almaden Research Center in San Jose. Western Digital Corp. provided the mathematical model for performance calculations while IBM has contributed in the form of...
Quality Review of Courseware on the NEEDS Database

- Establish credibility of NEEDS as a source of Quality educational material
- Enhance recognition of scholarly and creative effort of courseware developers

  - Peer/Expert Review of Courseware
  - Premier Award for Excellence in Engineering Education Courseware
The Premier Award for Excellence in Engineering Education Courseware

• A national competition to identify and reward the authors of high-quality, non-commercial courseware designed to enhance engineering education.
  – The *Premier Award* is about the entire experience of using the courseware by learners, not just the courseware itself

• A dissemination system to distribute the Premier Courseware (via CD’s and presentation at engineering education conferences).
Premier Award Criteria

We recognize that all the categories are interwoven.

• **Engineering Content**
  – Is the content error free?

• **Software Design**
  – Is it well designed and usable?

• **Instructional Design**
  – Will students learn from the courseware?

See [http://www.needs.org/premier/1999/criteria.html](http://www.needs.org/premier/1999/criteria.html) for more info
Evaluation Criteria

• **Instructional Design:**
  – Interactivity
  – Cognition/conceptual change
  – Content
  – Multimedia use
  – Instructional use/adaptability
Evaluation Criteria, cont.

• **Software Design:**
  – Engagement
  – User interface and navigation
  – Interactivity
  – Multimedia use
  – Technical reliability

• **Engineering Content:**
  – Accuracy of content
  – Organization of content
  – Consistency with learning objectives
Premier Courseware of 1997 & 1998

- Virtual Disk Drive Design Studio
- Drill Dissection and Bicycle Dissection
- Mars Navigator
- Della Steam Plant
- MDSolids
- Structural Engineering Visual Encyclopedia - UNH

3600 CD-ROMs Distributed
1800 CD-ROMs Distributed

For more info or to receive copies go to http://www.needs.org/premier/
Premier Courseware of 1999 & 2000

- Engineering Graphics
- Cracking Dams
- Submit for the 2000 Premier Award

1000 CD-ROMs Distributed

For more info or to receive copies go to http://www.needs.org/premier/
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Towards
A Digital Learning Space for Library for Science, Mathematics, Engineering and Technology Education
Should NSF Establish and Fund a National Science, Mathematics, Engineering and Technology Education Digital Library?

- **April 1996 - NSF Committee Meeting (LIBUSE)**
  - “Towards a National Library for Undergraduate Science Education Resources in Science, Mathematics, Engineering and Technology”

- **August 1997 National Research Council**
  - Digital National Library for SME&T Education Workshop

- **July 1998 National Science Foundation**
  - SMETE-Lib Workshop

- **January 1999 National Science Foundation**
  - Digital Libraries and Education Workshop

Funding through Digital Libraries Initiative – Phase 2
Vision of NSDL ...

“... a network of learning environments and resources for Science, Mathematics, Engineering and Technology education, will ultimately meet the needs of students and teachers at all levels—K-12, undergraduate, graduate, and lifelong learning—in both individual and collaborative settings.”
Needs Assessment with Members of the Math and Science Community

Purpose:
To understand the math and science communities of educators and examine their needs in order to design services and structures to support users from multiple communities.

Research Questions:
• What services, features & programs are integral to success?
• What do users expect with regards to quality of the holdings?
• Who makes up the SMETE digital library community?

American Association of Physics Teachers, American Mathematical Society, American Association for the Advancement of Science, members of the NSF Chemistry Consortia and the NSF Engineering Education Coalitions
Findings, Trends, & Design Implications

Quality

• Library as a marketplace/shopping mall of ideas and products
• Contents range from “works in progress” to highly rated products
• “Peer review” includes cognitive science, pedagogy, curriculum and user reviews
Findings, Trends, & Design Implications

Community
• Communication potential is most highly valued
• A place for networking, learning from peers and communication — not just a repository
• Users look to their peers first to learn about teaching — strong discipline identify

Contents
• Library holdings should be diverse:
  problem sets to entire courses, books to data sets, visualizations and simulations, instructors’ guides and assessment tools
Translating Findings into Services & Features

Quality

• System to rapidly identify the quality of holding
• Place to comment about a learning object or regarding something of interest to the community
• Reviewers should include experts in pedagogy and content
Translating Findings into Services & Features

Community

• Embedded structures for developing and maintaining communication links
• Developing community should be on par with building content
• Build on discipline based communities to establish connection to a broader community

Content

• Useful content and community interaction will ensure user participation as authors, reviewers, adapters/adaptors, and consumers
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Building a SMETE Information Portal

• Searching for learning resources
• Cataloging (adding) learning resources
  – Standards, IEEE and IMS
• Evaluating the quality of learning resources
  – “User” reviews
  – “Expert” reviews
• Forming a community of users in SMETE
• SMETE Digital Library Prototype Under Development based on NEEDS Infrastructure
  – User Comments (user-based reviews)
  – Adopted IEEE/IMS Metadata

• Expanded Collections
  – Expanding into Chemistry, Physics, and Mathematics

• Working with Partners
  – Eisenhower National Clearinghouse
  – Math Forum at Swarthmore College
  – Math Metadata Task Force

<table>
<thead>
<tr>
<th>Total Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
</tr>
<tr>
<td>Chemistry</td>
</tr>
<tr>
<td>Physics</td>
</tr>
<tr>
<td>Math</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>
Prototype
Project Goals

• Expand partnerships
  – Math Forum at Swarthmore College
  – University of California Nexus K–12 project

• Collaborate with partners to develop a prototype SMETE Digital Library
  – test interoperability of federated searches and shared services with partners
  – expand requirements analysis to include K–12
  – develop criteria and standards to assess the impact of learning objects across disciplines
  – implement community feedback systems and evaluate services
• Development of Best Practices of using metadata for the Mathematics community
• Development of subject thesaurus for range of mathematics resources
  – Level I: Pre-variable Mathematics
  – Level II: Post-variable, pre-proof oriented mathematics
  – Level III: Pre-professional and professional mathematics

www.mathmetadata.org
Challenges Toward the Future

- Understanding and supporting users’ needs
- Improving ability to encapsulate the instructional intent and use of materials
  - Metadata standards and cataloging practice
- Supporting communities of use and practice
  - pedagogy
  - content
- Which allows for a user to find what they’re really looking for as well as personalization of content.
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