

# Using the National Engineering Education Delivery System as the Foundation for Building a Test-Bed Digital Library for Science, Mathematics, Engineering and Technology Education

## C. Project Description

### C.1.0 Introduction

Two key National Science Foundation (NSF) reports, “Systemic Engineering Education Reform: An Action Agenda” and “Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology,” urge the formation of a national resource to provide access to quality courseware and to disseminate successful educational practices [57-58]. Since the early 1990’s, NEEDS — the National Engineering Education Delivery System — has provided these services for the *engineering* education community. In response to the Digital Libraries Initiative – Phase 2, section C.III, “Planning Test-beds and Applications for Undergraduate Education” we propose to build upon NEEDS as the foundation for a test-bed Digital Library for Science, Mathematics, Engineering and Technology Education (SMETE).

We propose to:

- (i) Develop a test-bed Digital Library for Science, Mathematics, Engineering, and Technology Education (SMETE Digital Library). By using the existing the NEEDS digital library as a foundation, we will be able to provide courseware<sup>1</sup> cataloging, indexing, searching and downloading to the science and math communities. In partnership with the nine campus University of California System and with assistance from NSF in identifying target projects, we will catalog the courseware necessary to form a test-bed SMETE Digital Library.
- (ii) Initiate development of a SMETE Digital Library user community. We propose to begin developing a broad SMETE Digital Library user community of science, mathematic and engineering developers, adapters, adopters and learners. We will use focus groups in science and math to perform a needs assessment, which will explore basic issues regarding system functionality, standards, reviews, etc. We will determine what features of NEEDS currently satisfy these requirements and what features are desirable, but missing or inadequate in the current system. In addition, we hope to identify the potential value of a full-scale SMETE Digital Library.
- (iii) Evaluate the test-bed SMETE Digital Library. We propose to develop evaluation processes, methods and protocols to be applied in the development of a full-scale SMETE Digital Library. We will prototype these processes in evaluating NEEDS and the test-bed SMETE Digital Library.
- (iv) Develop recommendations for NSF’s continued development of a SMETE Digital Library based upon our needs assessment and test-bed evaluation.

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<sup>1</sup> NEEDS defines courseware as instructional software and related educational material, such as videos, hardware and textbooks as well as an instructor’s guide and recommended pedagogical applications. Courseware can range in size from individual applets to term-long courses. It may be distributed by CD-ROM or World Wide Web sites.

## C.2.0 NEEDS — The National Engineering Education Delivery System

### C.2.1 The Current System

Synthesis: A National Engineering Education Coalition<sup>2</sup> ([www.synthesis.org](http://www.synthesis.org)) has been at the forefront of engineering education reform since 1990. NEEDS is the distributed architecture developed by Synthesis to enable new pedagogical models based on Internet-mediated learning environments [3, 9]. The emergence of the World Wide Web (WWW) in the early 1990's as a viable means for national and international sharing and re-use of education materials fundamentally changed our view of the way education and learning can be delivered. Internet-mediated learning environments provide mechanisms for the learner to be *anyone, anywhere, at anytime*. NEEDS currently catalogs courseware and other instructional technology developed nationally and internationally to provide a resource where both instructors and learners can search, access, and download educational materials. In addition, NEEDS supports a multi-tier courseware evaluation system including a national award competition — the Premier Award for Excellence in Engineering Education Courseware [29].

#### C.2.1.1 Background on the NEEDS Database

NEEDS is built upon international standards for data description (USMARC and emerging metadata descriptors) and data access (http and the World Wide Web), because they allow access to all users [69, 82]. NEEDS uses a robust structured query language (SQL) relational database to store and index courseware records. The underlying framework for these courseware records is based upon a standard library format for indexing and storing documents (USMARC) [69, 82]. The USMARC standard lets us apply a wealth of cataloging experience gained in the library community. Key to continued success is evolution, which currently includes adoption of the metadata descriptors developed by the Educom Instructional Management Systems (IMS) project (database fields in use by NEEDS for at least the last two years are nearly identical with metadata descriptors recently recommended by IMS) [42].

Our experience with NEEDS has led us to add self-cataloging features for author-initiated addition of materials into NEEDS. In addition, consistent with library cataloging standards, we perform a basic review of courseware as it is cataloged. We provide this review to insure that the courseware record has certain required fields — e.g., a title, author, publisher and platform (e.g., PC, Mac, or WWW); to perform a standard check for viruses; and to verify that the program can be operated on the intended platform(s). We use this basic functionality check in place of forced editorial oversight before courseware archiving; we have learned that it is counterproductive to introduce too many barriers to the cataloging process. Instead we have developed review systems to evaluate courseware once archived in NEEDS.

Each *bibliographic* record describes the pertinent information about the courseware, in the same manner that traditional on-line public access catalogs provide information on books (i.e., title, author, publisher, subject heading, keywords, etc.). A user can search for courseware by entering terms into a WWW form — Title, Author, Subject Heading, Keywords, or Platform. NEEDS then performs a Wide Area Information Service (WAIS)-indexed full text search to provide a ranked list of courseware (the higher the ranking, the closer the courseware matches the requested query) [3, 9]. The user can then view the *bibliographic* record that describes the courseware and provides hyperlinks to download the courseware for different platform(s). NEEDS goes beyond the traditional on-line library catalog by providing recursive search capabilities and additional guiding and organization structures [82]. Hyperlinks on the courseware record provide access to related information indexed along multiple axes (i.e., author, publisher, subject heading, and courseware

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<sup>2</sup> The Synthesis Coalition consists of: California Polytechnic State University, San Luis Obispo; Cornell University; Hampton University; Iowa State University; Southern University; Stanford University; Tuskegee University; University of California, Berkeley.

series). The capability to cross-index NEEDS courseware records provides a framework for extensibility. The hybrid capabilities in structured database queries (SQL) coupled with full-text search queries (WAIS) and our open architecture allows us to incorporate new research in controlled vocabularies and improved indexing and search algorithms. (See section C.4 for more details.)

Materials held in NEEDS are diverse — content ranges from single topics that can be covered in a few minutes to fully integrated, term-long courses. One of the most powerful concepts supported by NEEDS is courseware modularity, in some cases NEEDS catalogs courseware as well as the individual elements (e.g., images, videos, and text) that comprise the courseware. Courseware elements provide a vehicle for continued re-use of content material beyond the life-span of any particular courseware module. These elements can be used as is, or distilled from multiple sources and joined together to create new, customized courseware. Thus, the modularity supported within NEEDS is seen as a major enabling technology for fostering educational material adaptation and re-use.

### **C.2.1.2 Quality Review of Courseware**

Courseware on NEEDS, as with any scholarly effort, requires review to assure quality and provide recognition [29]. The Quality Review of Courseware effort was developed to advance the field of technology-enhanced learning review as well as continually raise-the-bar for excellent courseware. We worked with numerous experts (including students, engineering educators, instructional designers, cognitive scientists, and learning theory experts) to develop a scalable evaluation system that balances the trade-offs between scope, completeness, and expertise of the peer review with the time required to assess improved learning through use of courseware [29, 70]. The result is a two level review process. *Endorsed* courseware relies upon a gestalt evaluation to determine: if the engineering content is error-free; if the package is complete with author descriptions of content and recommended pedagogy; if the courseware is aesthetically appealing; and if the courseware is potentially useful to instructors other than the author [28]. *Premier* courseware is subjected to an extensive evaluation by a panel of experts (e.g., engineering educators, instructional designers, and students) who bring their respective learning perspectives to the review process. The *Premier* review focuses on the courseware's capabilities and if it has demonstrated enhanced student learning. Judges use author supplied evidence of student learning; evaluation and assessment guides; instructor's guides and recommended pedagogical applications; and evidence of adoption and adaptation by others to evaluate these criteria. John Wiley & Sons sponsors the Premier Award for Excellence in Engineering Education Courseware, an annual national competition that identifies *Premier* Courseware.

### **C.2.2 NEEDS and the NSF Engineering Action Agenda Grant**

NEEDS has recently been awarded a three year grant from the NSF Engineering Action Agenda program to provide services to the *engineering* education community through a proposal titled: "Expanding the National Engineering Education Delivery System as the Foundation for an On-line Engineering Education Community" [10]. From its inception NEEDS was conceived of and described as a digital library of courseware. However, based on our user studies and operating experience, NEEDS has progressed well beyond a manifestation of the traditional academic library in digital form, both in our target audience and in the services we provide.

Driven by notions of education and student learning, NEEDS also distinguishes itself from a commercial, Web-based search engine by providing focused, value-added services to our community. The success of NEEDS as a service depends not only on the development of a critical mass of content, but also on the development of a critical mass of viewership. The development of an on-line community — consisting of developers, adapters, adopters, interested parties and learners of the content made available through NEEDS — provides the means of sustaining NEEDS as a resource. The content continually draws the user back, and stimulates discussion among community members regarding adoption and adaptation of existing courseware, leading to new courseware development and courseware acquisitions. The community can address many of the concerns and challenges in

cataloging courseware (e.g., inadequate courseware description or lack of support material) by becoming a user-based support and evaluation system. Many of the new features we plan to add to NEEDS through the Engineering Action Agenda are focused at strengthening our present methods of review for all courseware within the system in order to help our user community evaluate whether to adopt or adapt a particular piece of courseware. (See pages C-14 and C-15 for a figure detailing the current and planned features of NEEDS.)

Using funds from the Action Agenda grant, we plan to add **Extended Usage Tracking** and **User Registration** to NEEDS. For the last three years we have relied on standard usage data generated by Web servers (e.g., browser-type and where the browser is located) to guide system development and features offered. However, Web usage logs do not allow us to easily couple information about what queries (searches) are performed with the results of that query, i.e., which courseware was presented, which courseware was downloaded, whether it was successfully downloaded, who downloaded it and why it was downloaded. To do this, we must institute a transaction-based system to track queries and their results. This system will allow us to provide authors with attempted download statistics and better understand our users' search patterns.

We also plan to institute a **User Registration** system for courseware downloads that allows us to map *who* uses courseware to *where* and *how* they are using it. This in turn facilitates longitudinal tracking and dissemination efforts for authors, and provides them with greater user feedback. We will track *successful* downloads with a follow-up survey to ascertain the adoption or adaptation of courseware; find similar or related courseware; and receive feedback for continuous system refinement. In addition, we will allow registered users to develop **User Profiles** through which we will proactively identify newly cataloged courseware of interest to the user. NEEDS thus becomes demand-driven by carefully targeting acquisition efforts toward identified content needs.



We plan to allow users to attach personalized **User Reviews** and supplementary **Support Materials** to the courseware bibliographic records. User Reviews will provide a wealth of community-based support for courseware. They may include information on a user's experience with the courseware and how a user employed the courseware — potentially expanding upon the author's original intent. A good example of User Reviews can be found at Amazon.com where book buyers can read reviews, written by other consumers, to better judge a book before making a purchase decision. Support Materials extend the catalog record by attaching user-provided links to related information.



We plan to continue to conduct **Endorsed Peer Reviews** and the **Premier Award**. As we do so, we expect to raise the expectation of what represents quality in courseware. In addition, we plan to develop **Feature Reviews**, similar to book reviews found in journals and newspapers.



We plan to add “off the shelf” threaded **Discussion** tools to further transform the static courseware record into a dynamic, living entity. These services extend the courseware record by providing a forum for users to discuss the courseware and its application.

### C.3.0 Proposed Work

Action Agenda funding provides support for NEEDS to serve only the *engineering* education community using “off the shelf” software tools, it does not provide sufficient resources to examine a SMETE Digital Library. The proposed Digital Libraries Initiative – Phase 2 funding, however, will allow us to develop a test-bed Digital Library for Science, Mathematics, Engineering and Technology, perform user studies on this test-bed SMETE Digital Library and incorporate research from other digital library projects.