The National Engineering Education Delivery System (NEEDS)
Supporting the Transformation of Engineering Education

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1.0 Introduction

Networked computers, the Internet and the World Wide Web, and other information technologies allow individual students the ability to locate and access a wide range of digital, educational resources as never before. Technology is opening the door for new methods to enhance and transform the traditional educational process. Engineering educators are being pulled into these new paradigms of information delivery by our students. The use of these state-of-the-art computer and information technologies challenge the traditional lecture model and force us to rethink student-teacher roles in the learning process. We are beginning to realize the paradigm shift from the teacher-centric lecture model to learner-centric, technology-assisted learning model that allows the student to control the learning process, with professors and instructors serving as mentors and guides.

NEEDS—the National Engineering Education Delivery System—meets the needs of this new age of learners by providing a digital library of engineering educational materials. Destined to be one of the lasting legacies of the National Science Foundation's Engineering Education Coalitions program, NEEDS meets the ever expanding need to archive, share, disseminate, and use high-quality digital engineering education materials. The NEEDS architecture consists of courseware creation, delivery, archive, and review. At the heart of the system is a database of courseware that is accessible through the World Wide Web at **www.needs.org**. The database and services available through NEEDS have been expanded and improved dramatically in the last year. NEEDS is building a high-reliability, scaleable system based around a relational database to offer Web based searching and downloading of engineering courseware.

NEEDS is pioneering the development of a comprehensive peer review of engineering courseware through our development of the NEEDS Editorial Board and the establishment of the Premier Award for Excellence in Engineering Education Courseware. The Editorial Board will oversee the "endorsed"-level of our multi-tiered review system. Based on the journal-model, the peer review process will result in "endorsed" courseware on the NEEDS Database—courseware that is technically correct and has potential value to an instructor/learner other than the author. A competitive review and evaluation process will be used to determine the winner of the Premier Award—the "best of the best" in engineering education courseware. These efforts to reward and recognize courseware developers will go beyond NEEDS and the database itself by recognizing the scholarly and creative efforts that authors have expended in developing, effective, high-quality engineering courseware.

The National Science Foundation has asked NEEDS to continue to grow and to include quality, digital engineering education materials nationwide. As NEEDS transitions to this national

resource, it fills the role as a clearinghouse for digital engineering educational materials. Nationally, interest exists for a "Library of Congress" of digital educational materials that includes the disciplines in Science, Math, Engineering, and Technology. The NEEDS system is designed to ultimately meet this vision of a digital library of educational materials.

One of the pressing needs in the age of change we are experiencing as engineering educators with the advent of ubiquitous, low cost computers, the network, etc. is a means of sharing instructional technology developed nationwide and worldwide. The costs and time involved to develop effective instructional technology that begins to reach some of the promises of IT requires enormous time commitments.

2.0 NEEDS Database

NEEDS provides an infrastructure linking the developers of courseware to users/learners of courseware. NEEDS is a location to archive, locate, and download courseware. The missing portion in most courseware submitted to needs is the pedagogy, instructor's guide, etc.

Courseware   Pedagogy
Course Elements   Instructors' Guide

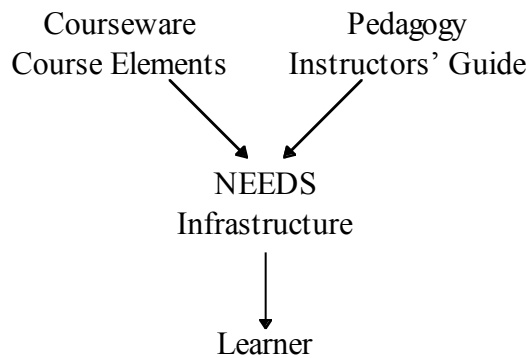NEEDS
Infrastructure

Learner

Figure 1. Combining Courseware and Pedagogy through the NEEDS Infrastructure to Support the Learner

The NEEDS infrastructure consists of database, web servers, backup/archive servers. Developed for scalability

to support the anywhere, anytime philosophy - first step is to make the information, in this case courseware and digital course support materials available to the learner at the time and place of his choosing. The explosion of the World Wide Web, ubiquity of computers and the network have made it possible for the average learner to gain access to this material at the time and place of their choosing. The first step in this process of making the information available is to develop an on-line repository of courseware. However to adequately support the learner, we need to provide additional support to the learner.

One way of classifying users of instructional technology is to describe them as developers, adapters, adopters, and learners.

- **Developers** - develop all materials from scratch or may use existing "building blocks" of videos, images, animations, etc. developed by others.
- **Adapters** - tailor existing courseware developed by others to fit their needs. They repurpose and/or build their own course support materials using course modules and elements developed by others.
- **Adopters** - use existing materials and use as an integrated whole. They take courseware developed by others and uses as-is with little or no modification.
- **Learners** - use the instructional materials to support their learning. In general, a learner may be a developer, adapter, adopter, a "student" taking a class in the traditional sense, or a "student" learning for personal edification or in a continuing education mode.

While the courseware and course elements that comprise the NEEDS Database are produced by Developers, the flexibility of the NEEDS infrastructure allows either the Developer or the adapters or adopters of the courseware to provide the pedagogy and instructor's guides for the courseware. Additionally adapters may combine multiple pieces of courseware

One of the most extensible series of items in the NEEDS Database are the Multimedia Case Studies of Engineering Design. Developed by the Synthesis Coalition, primarily at the University of California at Berkeley over the last four years, the case studies form an integrated whole that can be mixed and matched in the classroom. The computer-based or web-based case studies can be used individually by learners, in a group environment with facilitator lead discussions, combined with hands-on dissection exercises, etc. The use of the MMCS can be by junior high/middle school students, high-school students, freshmen, sophomores, juniors, seniors, through graduate students. ETC. Or can use Sheri Sheppard's example.

Have had multiple users adopt and adapt the MMCS to their particular learning environments world wide.

up until now the primary focus in the development of NEEDS has been building the database itself. We have been running parallel projects—namely the Quality Review of Courseware to provide more than just a database/repository of courseware. It stems from the belief that the use of instructional technology must be learner focused and must include pedagogical goals, etc. We've built the system to handle the technical aspects of storing, searching, and downloading courseware. This is what I call the service aspect of NEEDS.

3.0 Review of Engineering Courseware

The World Wide Web has become a widely accessible method of distributing and locating educational materials. In a sense the Web has democratized the process by allowing developers of instructional material to deliver that material to learners around the entire world at any given moment. As students, or more generally learners, and engineering instructors search pro-actively

for materials to support their learning and teaching, they need some indication of the accuracy and quality of the materials they find. For we have all heard how the World Wide Web allows everyone to be a publisher, yet does nothing to indicate the accuracy nor quality of the materials found.

3.1 Levels of Review

The Synthesis Coalition and NEEDS are developing a multi-tiered system of evaluating courseware to provide indications of quality for engineering courseware. These efforts have been underway for the past three years and we are now beginning to see the fruits of these efforts. We are developing three tiers of material in the NEEDS Database: unreviewed, peer reviewed, and Premier courseware. These three levels balance the need to support and encourage innovation in developing digital curricular materials; to provide the adopters and adapters with indications of quality materials and potential instructional value; to reward developers of courseware and it's associated educational experience; and to reward truly innovative courseware as the "best of the best."

> **Unreviewed Courseware** - This is the base of materials in the NEEDS Database. All courseware is subjected to technical evaluations by NEEDS Staff to guarantee that the courseware operates and has sufficient information for operation and cataloging. The unreviewed portion of the NEEDS Database parallels the notion of freeware and shareware.

> **Peer Reviewed Courseware** - This level indicates that the content of information covered by the courseware is technically correct and has the potential to improve learning. The gestalt review was developed to balance the need to provide quality control with the time constraints on our potential reviewers. The most general questions about the usefulness of courseware are covered here: Is content error-free? Are the target audience and educational goals consistent with courseware content? Can the courseware be used by an instructor other than the author? Should the courseware be Endorsed? When peer reviewing courseware, the reviewers will answer these basic questions using the criteria developed for the *Premier* Award as the basis for their decisions.

> **Premier Courseware** - This is the most rigorous level of review envisioned for courseware in the NEEDS Database. The *Premier Award* is a national award competition with a judging panel comprised of engineering educators, instructional designers, publishers, and students.

> *What is the Premier Award?*
> The *Premier Award for Excellence in Engineering Education Courseware* has been introduced to recognize high-quality, non-commercial courseware designed to enhance engineering education.

> *Why create the Premier Award?*
> Multimedia courseware designed for engineering education is being developed by many academicians who deserve recognition for their outstanding contributions to

enhance engineering education. Too often these developers receive little reward, either financially or institutionally, for their superb and time-demanding efforts. In addition, the use of multimedia technology in the classroom is expanding rapidly, yet many faculty integrating courseware into their classes are unsure of indications of it's quality.

The Synthesis Coalition (www.synthesis.org) and NEEDS (www.needs.org), along with our sponsor John Wiley & Sons, Inc., have developed *the Premier Award* to promote successful courseware, as well as provide models of excellence for educators planning to incorporate or develop courseware in the future.

—Excerpted from the *Premier Award* Information Brochure

3.2 Criteria for Review

The criteria are meant as a guide and represent our efforts to codify an evaluation process for courseware. In developing the criteria, Synthesis has taken a learner-centric outlook on the educational experience. We also build upon some of the latest thinking about higher education and value constructivist learning. Many of our beliefs about education are interwoven into the criteria we have chosen as well as how we view courseware that meet the criteria. We value courseware that includes learning goals and instructor's guides that prescribe pedagogical applications of the courseware.

There are a seemingly infinite number of ways to set forth criteria for evaluating courseware. In fact, in the process of developing the set presented below, we did keep rearranging the individual criteria. However, we settled on assigning criteria to three sections—Engineering Content, Software Design, and Instructional Design—because we felt that this division mirrored the evolution of courseware design and development by our target audience, engineering professors. The criteria we've developed are applied directly in the judging for the *Premier Award* and provide the intellectual framework for the peer review.

While we take a learner-centric view on the use of the database as well as the use of courseware, we nevertheless feel that the primary audience developing courseware will in the short term be engineering professors. Additionally, one of the primary goals of the Quality Review of Courseware is to develop an effective review system to appropriately recognize the development of courseware. In any event, we feel that the criteria we have selected meets the aforementioned needs as well as ensuring the primary goal of identifying accurate, quality materials for the learner that have the potential to improve learning/understanding.

Engineering Content - In this part, the courseware is evaluated solely on its content and the appropriate expertise is that of content area expert (i.e., engineer).
- Accuracy of content
- Organization of content
- Consistency with learning objectives

Software Design - In this part, the courseware is evaluated as a piece of software, although not necessarily as a piece of instructional software. Evaluated from the point of view of a software and interface designer, is the software generally well-designed, and is the end-user experience appropriate.
- Engagement
- User interface and navigation
- Interactivity
- Multimedia use
- Technical reliability

Instructional Design - In this part, the complete instructional experience (the courseware in its prescribed context) is evaluated using criteria that is indicative of success in promoting and supporting learning. The evaluation of courseware in this section goes beyond considering it solely as a piece of software. The entire instructional experience should be considered; factors contributing to this will include teacher interactions, off-line activities, and any other items described in the instructional guide.
- Interactivity
- Cognition/conceptual change
- Content
- Multimedia use
- Instructional use/adaptability

Over time, more important than the *Premier Award* itself will be the criteria and understanding that we develop in reviewing and evaluating quality courseware. While we have taken the first steps to codify an evaluation process for engineering courseware as part of a wide-spread dissemination system (i.e., the NEEDS Database), it is still an open research question on how digital instructional materials (i.e., courseware) can support and promote learning.

More information about the *Premier Award for Excellence in Engineering Education Courseware* can be found on our website at http://www.needs.org/premier/. We expect to publish a paper shortly that fully describes the criteria we have selected as well as details our experiences in developing an evaluation system for engineering courseware.

4.0 The Future

moving beyond just a repository of courseware.
can NEEDS (courseware) support asynchronous distance learning? what are the implications of a widely accessible source of
how do we encourage the development and research into the appropriate technology-assisted pedagogies?

how do we review courseware to "certify" or "validate" the content presented?

How do we encourage developers to include learning goals, instructors guides, and conduct serious evaluation of the effectiveness of their courseware?

How do we collect and provide information both to the author and to other users of courseware as to their adoption/adaptation by other learners and instructors?

What information does the learner need/find useful from a clearinghouse? From each piece of courseware available through that clearinghouse? Is the courseware effective in supporting the learner?

How do we go further to evaluate the new/experimental/non-traditional methods of finding information?

The database as a repository is of itself unique and necessary.
developing the Premier Award criteria it has become increasingly clear the lack/small quantity of time spent developing instructors guides, explicitly defining learning goals, including appropriate pedagogies

5.0 Summary

Time will cause us to rethink our conception of courseware. Is courseware a CD-ROM, Java applet, collection of Java applets? Courseware is a coherent group of educational support materials with a digital component. Courseware can be just part of a larger package to support some learning goal. Courseware can't do everything and we shouldn't expect it to. Although well designed courseware can be extremely flexible in how it is applied, it can be extensible beyond the author's original intent, and it often can be used in ways and scenarios the author didn't originally intend. In order to help the learner determine if the courseware can be used in any way, the learner must receive some statement of the learning goals, pedagogy, and intended uses of the courseware.

As mentioned with the Database courseware need not get used solely as the author intended. It may be extensible or used in different scenarios as developed by other learners and instructors. Thus the notion of a "community" of those interested primarily/at the start in engineering education is one mechanism to support this need.

While there have been numerous efforts to evaluate courseware and it's related educational experience, there have been no prescriptive studies to definitively prove how to develop courseware to promote learning. There have been numerous examples of anecdotal evidence to show that courseware can support and promote learning.

About the Author

Brandon Muramatsu is the Project Manager for the National Engineering Education Delivery System (NEEDS). He is involved with developing and implementing the NEEDS Database, locating outstanding courseware for inclusion in the Database, and ensuring quality content through the NEEDS Editorial Board. He works with the Synthesis Coalition and is headquartered in the Engineering Systems Research Center at the University of California at Berkeley. He has a Master's and Bachelor's degree in Mechanical Engineering from the University of California, Berkeley.

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Premier Award Information Brochure

Premier Award Website: http://www.needs.org/premier/