Online modules for Wood Design courses through NEESacademy

Abstract

The Wood Education Institute is developing a series of rich-media based learning modules to provide tools for teaching wood design. The modules that have been completed are intended for undergraduate programs. The modules currently under development target graduate level and continuing education study in wood design and focus particularly on the Network for Earthquake Engineering Simulation (NEES) related wood research efforts as part of a collaborative effort in engineering education. This paper describes the intent of these materials, pedagogical approaches for integrating them into university level courses, and results of a benchmark study of the material's use in a blended learning experience for undergraduate students at Cal Poly Pomona and Cal Poly San Luis Obispo universities. A survey instrument was used to capture students' perceptions of the learning modules from several dimensions including: relevance of content to career interests, relevance to course content, pedagogical approach, and usability. The survey results suggest that overall students had a positive experience with the learning modules. They appreciated the functionality that allowed them to control the pace of the content delivery and felt the materials were a strong contributor to their ability to use the knowledge as part of their class activities. While the majority of the comments were positive, there was data to suggest that the module content was too voluminous for the length (and pace) of the course and a shorter module length was preferred.

keywords: civil engineering education, design, learning systems, multimedia, distance learning, blended learning, wood design, wood, online module, wood education, NEESacademy.

Introduction

Wood is one of the oldest, environmentally sustainable construction materials. Approximately 90% (U.S. Department of Housing and Urban Development, 1994)[1] of all residential and 11% of non-residential (USDA Forest Service, 2008) [2] structures in the United States are built using sawn lumber and engineered wood products. [1] These modern engineered wood systems require specialized design and materials' specification knowledge. However, contrary to the public need for education in this area, a significant number of Civil Engineering programs do not offer a course on wood design, offer it as a part of another course, or, in some cases, offer it biannually, tri-annually, or sporadically. The report (Barnes 2007) [3] presented at the 2007 NCSEA Annual Conference on US higher education institutions that offer degrees in Civil Engineering demonstrated this educational deficiency. This was further supported by an informal survey conducted by the Wood Product Council in 2007 as well as numerous comments by the participants of the 2008 Structures Congress "Wood Engineering Challanges in a New Milenium: Research Needs" Pre-Congress Workshop. These reports, surveys, and workshops re-affirm concernes voiced by the wood industry leadership regarding the lack of wood design education in Civil Engineering programs. A recent survey (Cramer, 2011)[4] indicated that slightly over 50% of Civil Engineering programs offer a wood design course. In contrast, steel

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[1] Engineered wood products, or manmade wood, are wood products that are manufactured using combination of wood or wood fibers or other wood ingredients and resin. Commonly available engineered wood products include: plywood, oriented strand board (OSB), Glued Laminated (Glulam) beams and columns, laminated veneer lumber (LVL), cross-laminated timber (CLT) and etc.

and concrete design courses are offered with regularity at almost every university and are either part of a core curriculum or regularly offered electives. In addition to pointing out the deficiencies, the survey suggested the likely reasons for Universities not offering wood design courses. These reasons are summarized as: a lack of faculty or expertise in the area, budget and faculty load issues, and a general belief that wood design is too similar to steel and concrete and thus does not justify separate course. The lack of available expertise and faculty in the area of wood engineering can be traced to historically limited US research opportunities related to wood design. This, over time, has produced a scarcity of university faculty interested and proficient in wood engineering. Consequently, the US lags behind Canada and Europe in wood design innovation and availability of human resources to effectively teach the subject.

Recently, in the United Kingdom, a 9-story wood building was constructed using cross-lamintaed timber, an engineered wood material that has been used in Europe for the last 15 years but has yet to make it into standard construction practices in the US.[2] There has been a growing world recognition of the sustainability of wood as a structural material and also its carbon negative impact on the environment. Canada with its vast forestry industry and wood resources is actively leading the efforts in promoting what they refer to as worldwide "Culture of Wood". In 2009, British Columbia adopted Wood First Initiative: Wood First Act (2009 Legislative Session: 1st Session, 39th Parliament, 2009)[5]. This initiative requires that wood is considered as the primary building material in all new publicly-funded buildings in accordance with applicable building codes. This first step in Canada's fascilitation of the wood use action plan is also spilling into the United States. The Northwest states are debating similar initiatives and the State of Oregon attempted, although unsuccessfully, to adopt similar legislature in 2011.

In February of 2008, the Wood Products Council (WPC), a cooperative venture of the major wood associations in North America in partnership with research organizations and government agencies, launched WoodWorks. This initiative was designed to support the use of wood in non-residential building applications. The WoodWorks initiative was formed with the intent to provide a one-stop access to the widest possible range of information on the use of wood in non-residential structures to design professionals.

In July of 2008, WoodWorks announced an educational partnership with California State Polytechnic University Pomona and provided a seed investment grant to fund and create Wood Education Institute (WEI) program. This pilot program is a virtual learning model intended to assist in offering wood education for undergraduate, graduate, and continuing education programs nationwide. At the time of authorship of this paper the WEI has (1) developed a significant portion of the educational content that focuses on undergraduate programs interested in offering a course in wood design; (2) started development of modules targeting graduate students in cooperation with NEES related wood research educational outreach efforts; and (3) began development of a hybrid course with12-weeks of 100% online activities and a in person two-day weekend hands-on workshop as part of a continuing education program for practicing professionals.

[2] The ANSI manufacturing standards for this material has been adopted by the industry in 2011 and design guidelines will likely be adopted in 2013

For delivery of the completed modules, the WEI began a cooperative project with NEES (Network of Earthquake Engineering Simulations) to host the WEI developed courseware on their NEESacademy powered by the NEEShub infrastructure. Starting in late 2010, the intent of the collaboration was to apply developed methodologies to the NSF sponsored NEES Education Outreach and Training (EOT) programs. In the spring quarter of 2011, the pilot program was launched using Moodle, an open-source learning management system, housed and maintained by NEES (www. nees.org). The pilot program, using the online course content provided by WEI, launched the hybrid /blended timber undergraduate design courses at two separate universities as a first step toward implementation on a broader scale.

This introductory paper outlines the WEI framework as a work in progress vision consisting of a Virtual Classroom, Virtual Laboratory, and Virtual Studio as three pillars of the Virtual Learning Environment. At the time of the authorship of this paper, the Virtual Classroom model has been launched and student assessment has been conducted at California Polytechnic State Universities at both Pomona and San Luis Obispo. Presented herein are details of the WEI framework, the pedagogy of the packaged curriculum with the available online streaming teaching modules, details of the launched pilot program, and students' perceptions of the pilot program course content and its delivery through the NEESacademy powered by NEEShub.

Wood Education Institute

The Wood Education Institute (WEI) was established to address the growing need to educate undergraduate and graduate engineering students and the design professionals about issues and opportunities in designing architectural structures with wood materials.

The primary goals of WEI are to:

- Improve education related to effective use of wood as structural material.
- Establish and maintain an inclusive model of cooperation between industry design professionals and universities.
- Develop state-of-the-art virtual learning model for engineering education.
- Develop and implement entrepreneurial (self-sustaining) model for WEI operation.

The WEI presently maintains an Advisory and Development Board. Both boards composed of engineering educators, design professionals, and industry representatives. The list of participating individuals and the entities is available on the WEI website (WEI, 2010) [6]. The primary role of the Development Board is to create educational content in a modular format allowing flexible packaging of wood design content into a variety of course offerings (e.g. professional development modules and higher education courses).

Virtual Learning – The WEI Framework

Approach

The learn-by-doing[3] approach to engineering education practiced by the Cal Poly University, San Luis Obispo and Pomona are currently done in a traditional classroom environment consisting of lectures, lecture notes, homework, exams, and testing/design lab activities. An early WEI challenge was to develop a model that can replicate the learn-by-doing classroom success in an online or hybrid learning environment while effectively addressing the needs of civil engineering education. A three prong approach was selected to engage students in a learning sequence of reviewing materials in preparation for hands on testing or design exercises. The three prongs consisted of the Virtual Classroom, Virtual Laboratory, and a Virtual Design Studio (Figure 1). Each prong of the approach utilizes various methods of instruction to support learning with understanding. The Virtual Classroom provides rich media productions to familiarize students with basic facts and concepts associated with wood design. Traditional classroom lectures extend these lessons through didactic teaching and discussion with students to support their conceptual understanding. Virtual Laboratories engage learning in experiments were they use what they know to predict, observe an experiment in action, then explain results. The final application of their knowledge is tested in a Virtual Design Studio. It is here where students combine learned skills and apply their knowledge to various realistic design conditions.

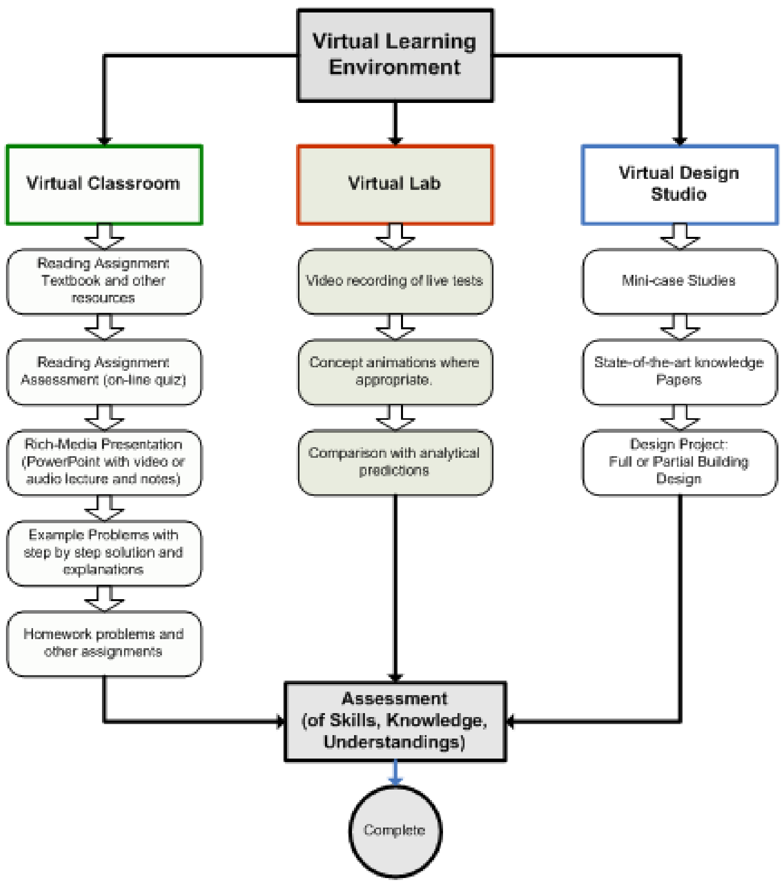

Figure 1 – Virtual Learning Environment

[3] The term "learn-by-doing" is used by California State Polytechnic Universities to describe hands-on learning pedagogy. This terminology is incorporated into university vision and core values and is representative of the universities' culture.

Virtual Classroom

The proposed Virtual Classroom content described in this paper could either be used to refine the activities of a traditional classroom by introducing digital media into the instructional sequence or be offered as a fully integrated virtual learning environment.

In the context of a fully integrated learning environment, it is proposed that the students be required to:

(1) Complete reading assignments
(2) Participate in the assessment of the assignments
(3) Proceed to viewing lecture content consisting of a rich-media Web-based asynchronous presentation, similar to what is being offered in growing number of educational webinars
(4) Take a short online quiz focused on key concepts to be learned
(5) Participate in forum discussions where areas of difficulties are identified and discussed
(6) Complete homework assignment graded by the course instructor or facilitator
(7) Participate in the final assessment.

Most of the pedagogical components of this process are fairly standard and can be developed individually by the educator facilitating the Virtual Classroom. However, the rich-media content of the subject matter is the most complex, time consuming, and expertise sensitive component. The WEI has developed approximately 15 hours of rich-media content divided into 30-60 minute modules. Each module provides a piece of conceptual knowledge associated with wood design. The modules are narrated streaming slides that introduce key concepts, vocabulary, illustrate difficult concepts using animations, and contain fully worked out examples. The modules are set up to allow students, at any time, to stop and go back or forward to review the material. The primary focus in the Virtual Classroom environment at this point, is to develop basic skills and, knowledge that prepare students to deepen their conceptual understanding in the Virtual Lab and Design Studio. This combination aligns well with the How People Learn Framework. (Bransford et al 2000)[7]. Figure 2 illustrates the screen shots of sample modules. Note that the students have access to the text associated with each slide and also can navigate to any slide in the presentation at any time.

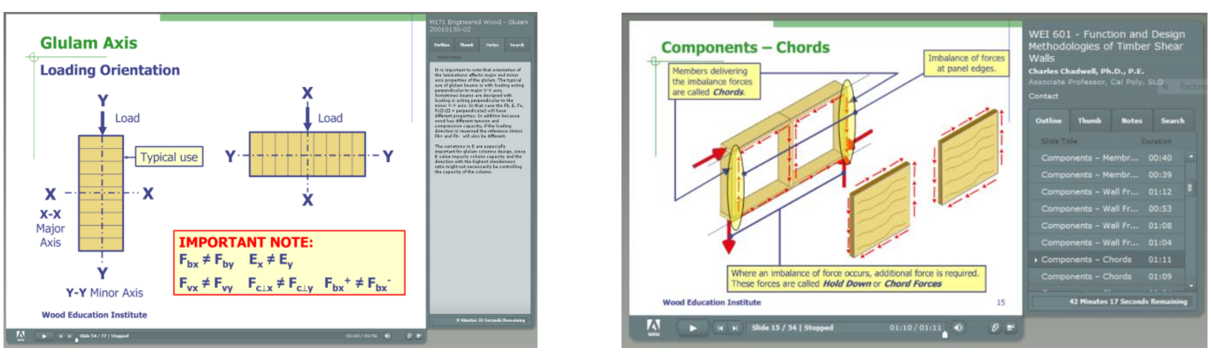

Figure 2 – Screen examples of WEI modules on various topics

Virtual Laboratory

One of the challenges of the Virtual Learning environment is the lack of access to "hands on" laboratory experiments. This creates a void in ability to achieve desired academic outcomes for classrooms that depend on a laboratory component. Currently, the Civil Engineering program at Cal Poly San Luis Obispo relies on laboratory hands on experiences to augment classroom lectures. However, the program at Cal Poly Pomona does not require a laboratory component for this course. The basic concept of the Virtual Laboratory is meant to bring laboratory experience to students where access to a traditional physical laboratory is not available.

The Virtual Laboratory components are comprised of four experiments identified as representing the basic laboratory experience necessary to complement classroom activities in wood engineering. Several hours of video footage were taken during live student laboratory sessions and were used in the creation of these Virtual Laboratories.

The format of the Virtual Laboratory (regardless of the experiment) is consistent. Each experiment follows the same methodology, has the same appearance, and is consistent with the WEI learning objectives. In each laboratory, at a minimum, there are the following sequentially ordered student/web site interactions:

- **Introduction**: This section includes supporting information and reasons for the experiment, the description of the experiment, details regarding the experiment to be conducted, and student learning objectives that are to be satisfied upon completion of the experiment.

- **Background and Pre-Test:** Background reading (consistant with that required by the Virual Classroom component) is required prior to starting the experiment. Each experiment is part of the larger learning objectives and chronologically coincides with assigned educational modules and reading material. Prior to the begining of the experiment, the student is required to pass a pre-test to verify their readiness to conduct the experiment. This pre-test is outside of the Virual Classroom environment and is specific to the labratory experiment. This pre-test includes questions about general knowledge as well as calculations to predict outcomes from the experiment. The main purpose of the background and pre-test is to ensure that the student has sufficient physical understanding of the experiment to calculate the experimental outcomes using the engineering principals.

- **Physical Experiment**: After succefully passing the pre-test, the student is taken to the main experiment page. This page contains video clips of actual experiments conducted in the Cal Poly San Luis Obispo laboratory as well as real time data collection. The video is an edited compilation of footage showing the overall experiment, close ups of the failure location, and a live speaker highlighting the key concepts consistant with the learning objectives of the expermiment. The student is responsible for collecting pertinent data as it is presented in the video of the laboratory experiments (similar to the note taking requirements of the students that were part of the actual labratory). The data is collected in the form of note taking during the video. A screeen shot from the virtual lab module related to wood beam testing is shown in Figure 3. It is divided into four windows: the test sequence window, the load-deformation curve window, the actual test video window and an annimated replication of test window.

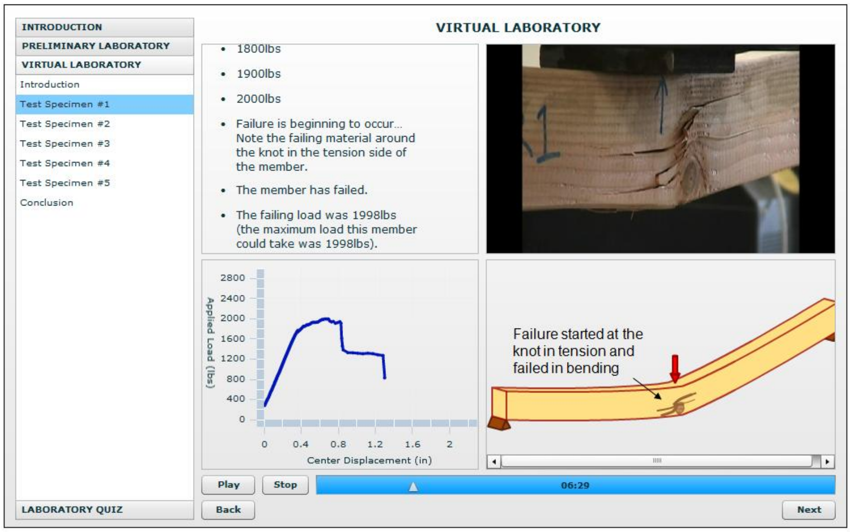

Figure 3 – Screen Shot of a Virtual Lab Module

- **Post-Test**: Using information learned from the experiment, students will be asked to answer a number of questions pertaining to both the experiments and the experimental outcomes. The post-test will serve as a measure of the students' synthesis of the required learning objectives.

At the time of authorship of this paper, the Virtual Laboratory is under development with two virtual lab modules completed and two more partially completed. These modules are not yet available to the public.

Virtual Design Studio

Another critical component of traditional engineering education, that is a major challenge for the Virtual Environment, is the hands-on design experience. The Virtual Design Studio is intended to provide students with the opportunity to apply learned skills and knowledge in a "near" real life design environment. This particular element of the studio would require access to Computer Aided Design (CAD), Building Information Model (BIM), and design and analysis software. This phase of the project is still in conceptual stages and its implementation relies heavily on technology developments and the delivery method selected. The following is a visionary description of the student's experience.

The studio experience will include a combination of mini-case studies, writing of state-of-the-art knowledge papers, and partial and/or full design of a structural system based on architectural plans. The mini-case studies will require evaluation of a specified component of a structural system of a wood building or bridge. The students will be required to prepare a report and an accompanying short presentation that will be available for sharing online with the class. The state-of-the-art knowledge paper will require the students to perform literature research and synthesize it into a short document. This document will be made available to others in the course.. The final component of the studio will require students to perform a design of a structural system from a set of architectural drawings. The project will include preparation of structural calculations, development of structural plans, sections and elevations, and design and detailing of key connections.

Content Delivery and Creation Technology

The technology used to construct these environments is a critical ingredient to successful implementation of the WEI Virtual Learning Environment. The technology can be categorized into two groups: content creation and content delivery (Figure 3). The software for creating rich-media content components is standardized on various Microsoft and Adobe products (such as PowerPoint, Word, Flash, Premier, Photoshop, and Illustrator). However, the software for combining these into a rich-media Web-based content has a limited number of choices. Adobe Presenter and Connect were selected primarily for their simplicity and availability. The enterprise level products by other companies offer long-term comprehensive solutions, but require significant initial investment. The ongoing changes in technology will present issues with long term maintenance and compatibility of the content. For example, the iPad and iPhone phenomena and its incompatibility with Flash have created challenges in delivery flexibility.

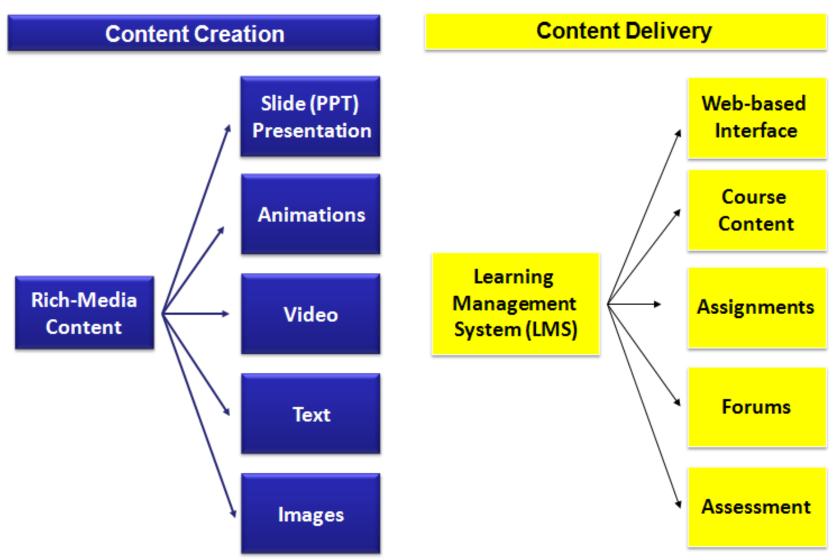

Figure 4 – Technology components (content creation and delivery)

NEESacademy powered by NEEShub and Moodle

The content hosting and delivery of the WEI modules for the virtual classroom initially presented a significant challenge because of a lack of delivery options. However, NEES has developed a cyber-infrastructure designed to support the research community's ability to share resources and build new knowledge through data sharing. This infrastructure proved to be symbiotic with the needs of the WEI. NEES adopted an open source solution called HUBzero[8] to create NEEShub which now powers their website presence nees.org [9]. One of the adaptations includes the construction of the NEESacademy designed by the NEES Education Outreach and Training (EOT) Team. They developed a mechanism to support online courses to support workforce development in academic and industrial settings. They integrated the open source course management system, called Moodle, into the NEEShub architecture creating an import delivery system in their NEESacademy. This capability provided an excellent solution to distribute the WEI learning modules. The screen shot of the NEEShub courseware entry point and the first page of the online modules access are shown in Figure 5 and 6 respectively.

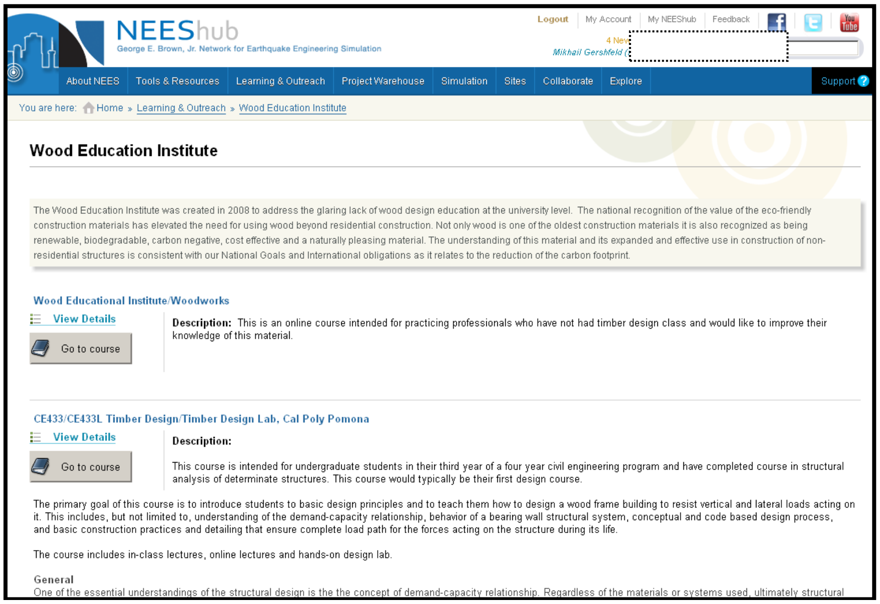

Figure 5 – Wood Education Institute Screen

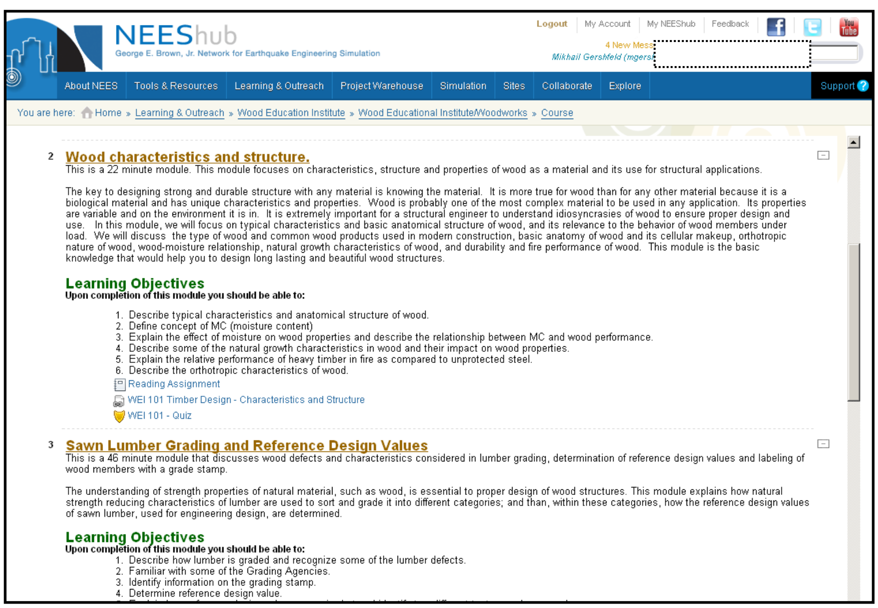

Figure 6 - Wood Education Institute/Woodworks Modules Screen

Student evaluation of Learning Modules

The Virtual Classroom portion of the Virtual Learning Environment was evaluated in a web assisted and hybrid course offerings at two universities over a period of three quarters (10 weeks each). Participants in these course were third and fourth year students in mandatory courses in Civil Engineering (N=79 total). The courses were designed as a blended learning experience which used the WEI learning modules as a pre-lecture activity designed to prepare students for more in-depth learning experiences in the classroom and physical design studio learning environments. The major target for evaluation in this study was on student's perception of the modules as a learning tool. A student self report survey was developed to target four major dimensions of the learning modules including:

1. Educational content – four items measured students' interest and perceived value of the content of the modules toward their current and future goals.

2. Educational Approach – four items measured students perceptions of the value of the modules toward achieving the course goals.

3. Evidence of Learning – contained six items to measure students' perceptions of how well they learned the content to perform various tasks in the course (quizzes, comprehending lecture, design project, etc.).

4. Usability – two items measured students' perceptions on how easy it was to use NEEShub and the learning modules.

The designers of the WEI content had specific aspects of the learning experiences that realted to these dimensions. A simple Likert scale was provided for students to rate how much they agree with the statements' alignment with their experience. For example, a general statement was asked "I had a positive experience with WEI modules" to which the students could rate as either strongly agree, agree, disagree or strongly disagree. Appendix A contains the actual items. Students were also given the opportunity to share their thoughts through several open ended questions soliciting what they found useful, needing improvement, and their own recommendations for improvement.

Students were asked to complete the survey at the end of the course. Participation in the survey was both anonymous and voluntery. The survey completion rate was 80%.

Results

The major goal of this study was to capture students' perceptions of their learning experience with WEI learning modules in the Virtual Classroom. Figure 7.1-4 summarize students' rankings of various aspects measured in each of the four dimensions of the student survey.

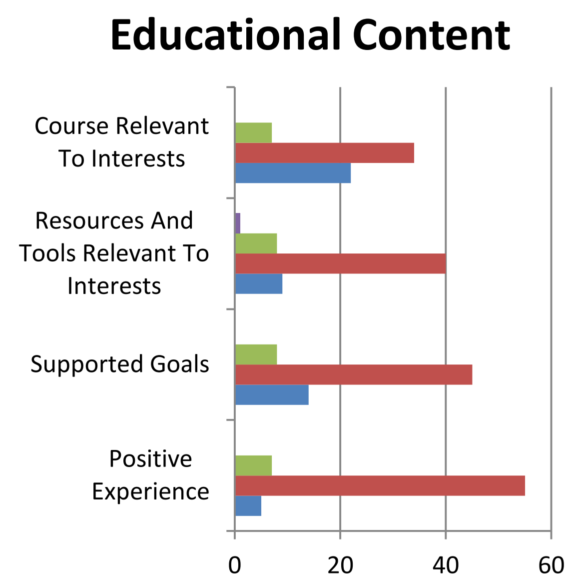

Figure 7.1

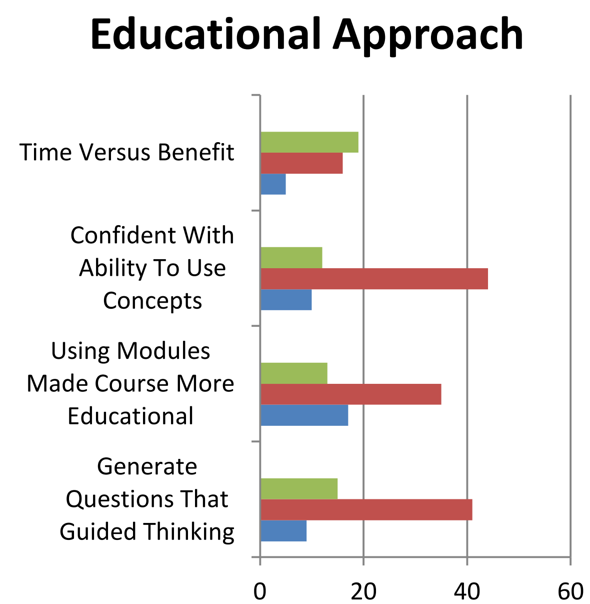

Figure 7.2

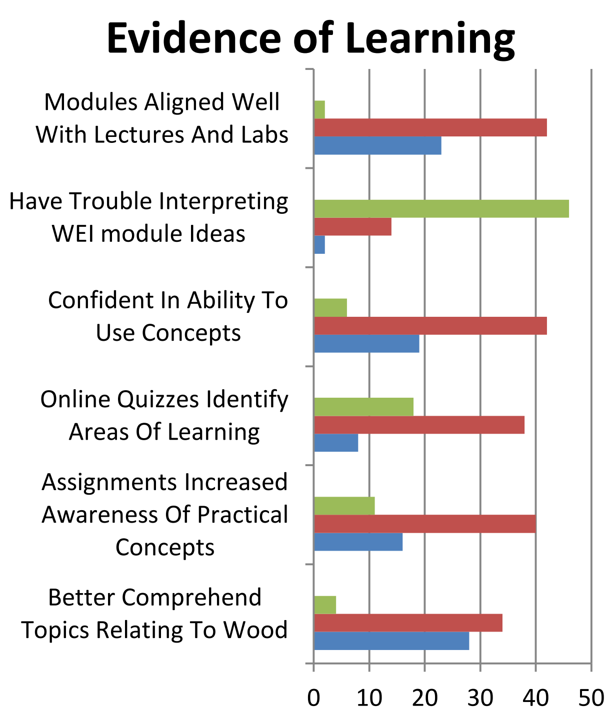

Figure 7.3

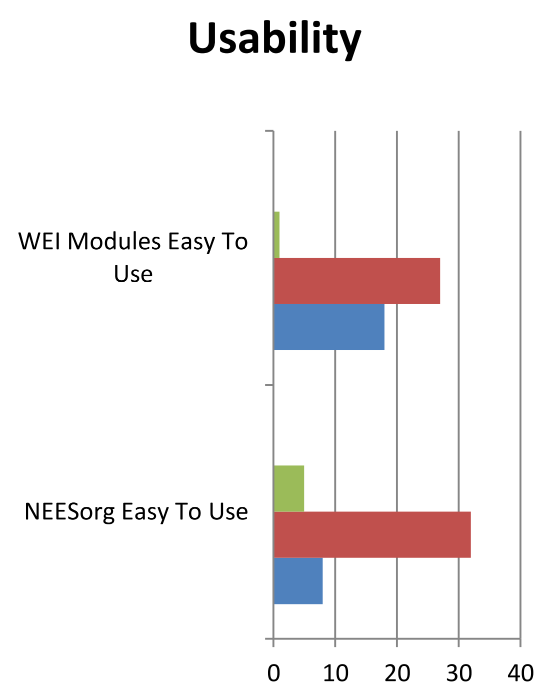

Figure 7.4

Strongly Disagree Disagree Agree Strongly Agree

Figure 7 - Summary of results from student survey

The open response questions were analyzed using a simple open coding method. Each response by the students was given a short description label identifying the general category of the response. Then a simple frequency response of these categories was used to provide a short summary of general issues and opportunities that students shared on the survey.

Almost all students reported having a positive experience with the WEI modules used in the course. The "Disagree" assessment appears to emerge primarily from technical difficulty with accessing the materials. This is seen through associations with the usability result which were also very favorable. More specifically, the majority of students agreed that their experience with the WEI modules:

- Aligned well with their interests and career goals
- Contained relevant content to the course and was beneficial and worth their time
- Materials stimulated their question asking
- Materials prepared them to participate in design activities (with knowledge and confidence) to apply what they learned.

From the qualitative results, one positive aspect of the learning modules was the ability to regulate the learning pace. The ability to pause, rewind and review multiple times put important controls into the students' hands. Similarly, students remarked that the dynamic visual effects provided an additional layer of information making it easier to comprehend the materials. The major drawback identified by students was the amount of content covered in the modules. They identified this hindrance to their learning with the module and recommended shortening the modules.

Conclusion

The virtual delivery of educational material is the next major revolution of the information age and it has already started. Webinars are being offered on variety of subjects and many reputable universities are either offering, or experimenting with offering, a variety of programs/courses partial (hybrid) to fully online. The progress in e-book technology and proliferation of electronic pads and the growing acceptance of digital information models for design and construction are rapidly changing the flow of information in design. The educational process needs to keep up with these changes and explore the opportunities they present for higher education. The realization of the WEI vision as outlined in this paper is still in the early stages. This introductory paper provided a work in progress summary of the WEI efforts thus far.

Blended courses in undergraduate Timber Design have been offered at two Universities with the completed modules integrated into the instructional process. Student survey results suggested that overall; these modules were effective in disseminating the requisite material and were positively rated by the students. After some additional refinement, these packaged modules will become available for public access to engineering educators with the intent to assist undergraduate programs interested in offering Timber Design in development of their own courses or providing opportunity for students to take courses online offered through WEI. The developed WEI modules are currently being assembled into a 12 week hybrid course to provide continuing education opportunity for the practitioners wishing to learn (or review) the undergraduate level material. At the graduate level, advanced topics modules are being developed and the WEI module approach is also being used to develop advanced content as an integral part of an educational outreach component of a particular NEES/NSF supported wood research project. The availability of content for undergraduate, graduate and continuing education programs to the academic community is intended to help to improve engineering education related to wood design, disseminate wood related research findings in an educational format and hopefully increase the usage of this sustainable material in the engineering practice.

Acknowledgement

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