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NEES ACADEMY: AN EDUCATIONAL CYBERINFRASTRUCTURE FOR THE EARTHQUAKE ENGINEERING COMMUNITY

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ABSTRACT

The earthquake engineering community has many constituents, each with their own interests in various aspects of science, engineering, education, and research. Researchers and their graduate students push the boundaries of current knowledge to identify new methods and devices to minimize earthquake impacts. Engineering undergraduates want to know more about how they can apply what they are learning to practical applications such as improving seismic design or reducing liquefaction potential. Practitioners are interested in learning about how current research findings can inform their designs. Educators are looking for materials to teach their students fundamental engineering principles and would like to use earthquake engineering as a context for delivering content and motivating students. New cyberinfrastructure tools are making it possible to provide each of these constituents with access to a rich set of resources they can use to guide their own learning or participate with an instructor's guidance to learn about earthquake science and engineering. The NEES Academy, being developed as part of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) operations, is designed to meet all of these needs. The Academy builds on a cyber-technology that supports the delivery of resources such as complex computational simulations, learning modules, visualizations, multimedia presentations, video resources and interactive games. In this paper we provide a brief vision for how this cyberinfrastructure will be used to create advanced online learning experiences for many different stakeholders including educators interested in advanced methods for implementing effective instruction.

Introduction

The mission of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) is to provide infrastructure for researchers to produce new knowledge and tools that will contribute to reduction of damage and losses from earthquakes and tsunamis. Developed in the early 2000s and officially opened in October 2004, NEES comprises 14 advanced equipment sites connected by an advanced cyberinfrastructure that enables rapid data viewing and analysis, remote viewing and participation, the ability to run interconnected experiments using several sites, and data archiving. Test equipment includes shake tables, geotechnical centrifuges, large-scale test facilities, field testing equipment, and wave tanks. Experimental research to date spans

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a wide range including evaluating new energy dissipation technologies and structural systems, understanding the performance of existing buildings and infrastructure, validating retrofit technologies, simulating the impact of tsunami run up, and validating analytical models with experimental data (Buckle & Ramirez 2010). Research using the Network can address almost any technical question associated with the effects of earthquakes and tsunamis on the safety of the built-environment.

Education, Outreach, and Training Program

To maximize the impact of NEES, research discoveries and recommendations must be widely distributed to the many earthquake risk mitigation stakeholders including current and future researchers, practitioners, educators, decision makers, and the general public. NEES research productivity hinges on investigators being proficient with state-of-the-art resources and being able to transfer knowledge fluidly between investigators. Researchers must understand the capabilities and limitations of resources such as large-scale shake tables and wave tanks, advanced sensing equipment and the NEEShub computational models that can interface with this equipment. Access alone is not enough for researchers to conduct innovative groundbreaking research and transfer that knowledge into application. The Network needs a way to provide effective and efficient access to information and learning materials for all potential stakeholders in the community.

The NEES Education, Outreach, and Training (EOT) program aims to be a focal resource for education and outreach for the earthquake engineering community. The EOT program supports education of engineering students, future researchers, and practitioners; dissemination of research findings; and promotion of NEES sites. The EOT program is managed by a seven-person development team with expertise in earthquake engineering, engineering education, instructional design, computer programming, web design, and public relations. The EOT development team is part of the NEES management team, called NEEScomm, located at Purdue University.

To reach the broadest audience, NEES must make use of the Internet. The EOT program can capitalize on the advanced cyberinfrastructure delivered through HUBzero™ (Klimeck et. al, 2008) technology. HUBzero is a platform containing special middleware capable of accessing research grade simulations through standard web browsers along with other tools to support collaboration, visualization of data and delivery of other web-based resources. The platform also provides mechanisms for members of a community to contribute resources for others to access. This HUBzero technology is being adapted into NEESHub to support research and promote a deeper understanding of earthquake engineering and mitigation to various stakeholders (Eigenmann et al. 2010). The NEES EOT community and the NEES development team can develop pedagogically-sound learning modules and resources, online training activities, interactive games, webinars, podcasts on NEEShub. In addition the NEEShub will host seminars, meetings, and high-quality publications in more traditional delivery modes to address diverse needs. A central element of the EOT program is the ***NEES Academy***, currently under development and an integral part of NEEShub.

NEES Academy

NEES Academy, a web-based virtual learning institution dedicated to providing learning modules and resources to meet learning objectives for practitioners, researchers, researchers in training, and educators and their students. Using the advanced capabilities of NEEShub, the Academy will be able to provide a range of materials such as individual learning through online modules, tools to support collaborative design and research-grade simulations and models accessible to educators and students of all ages. While the NEES Academy will incorporate materials for all audiences, development of resources and learning modules, at least initially, will focus on web-based learning materials for target audiences of undergraduate and graduate engineering students, and NEES researchers. As a unifying tool for EOT, the NEES Academy will provide the multiple advantages of disseminating EOT resources to broad audiences, and supporting EOT expertise at equipment sites and on NEES research projects. Developers at NEEScomm will work with investigators within NEES to provide guidelines and production support for designing effective learning resources. The goal is to increase the potential for consistent and high-quality learning resources for the earthquake engineering community.

The NEES Academy will be founded on principles of effective teaching and learning (e.g. Bransford et al, 2000; 2005). NEES learning materials will use a modular architecture consisting of research, learning objects, and learning modules which will increase the potential usability and reusability (Brophy 2003). This modular approach facilitates repackaging and repurposing materials; for example, a video can be the centerpiece of several modules, each aimed at a different audience or achieving a different learning objective. The learning materials will have a signature appearance that includes learning objectives and outcomes, suggested assessments, background material, lecture notes, references, a suggested schedule for implementation, standardized use of NEEShub resources, and suggested assignments. This consistent design method and appearance should increase the chance for educators to successfully adapt and adopt these shared learning modules, and users should be able to easily adapt to the modules because of the consistent organization and presentation of materials, all based on proven pedagogical approaches to learning engineering (e.g. Roselli & Brophy, 2006; Bransford et al; 2005; Prince, 2004).

Developers at NEEScomm will utilize advanced web authoring tools (e.g. CAPE – Course Authoring Packaging Environment) to support researchers in transforming their current education and outreach activities or research products, into NEES Academy learning resources and modules. These learning resources and learning modules could include traditional learning technologies such as demonstration videos explaining theoretical concepts, videos highlighting research projects or webinar archives accessible as podcasts. Researcher-developed activities generally aim to achieve very specific goals, but with the support of the NEEScomm team and the NEES Academy these resources can potentially be reused in learning modules with different learning outcomes. For example, experimental data and an accompanying video of tests on concrete columns can illustrate ductile and nonductile behavior under various test conditions. The instructional materials could be aimed at graduate concrete design and augmented with exercises and class discussion to generate computational models to emulate the empirical results. The same video could also be aimed at undergraduates first studying materials and how they behave under dynamic loading conditions and how to conduct tests to evaluate various design

options. Or the video could be used in a module on understanding different engineering careers, aimed at freshmen. As the Network matures and its members contribute resources, the number of on-line simulations and computational models will increase. These contributions will provide additional learning resources the EOT development team can repurpose for a wide range of learning outcomes. Ultimately the NEES Academy will be a place for people to access these learning materials as well as upload their own resources to be used by others.

NEES Academy Content

During the first five years of operation, NEES research projects generated many interesting videos that illustrate earthquake impacts and highlight particular experiments. These were posted on the NEES Channel on YouTube. More can be done to anchor these resources into interesting learning modules that illustrate how these experiments contribute to the larger community goal of reducing losses in future earthquakes. The NEES EOT development team plans initially to develop modules aimed at REU students, and seniors or masters-level students taking their first course in earthquake engineering. The modules will serve as interactive introductions to the motivation for and experimental techniques used to investigate the various research questions. The development team also anticipates repurposing these materials for the public and a more general audience.

Currently, each NEES equipment site designs and administers training for its own facilities. The NEES EOT development team anticipates making these training efforts more effective by augmenting current training workshops with real-time video streaming, short podcasts of FAQs, and online "how-to" videos. The NEES EOT team will work with individual equipment sites to develop online learning modules of their training or complementary materials to enrich the experience for participants, all of which can be delivered through the NEES Academy. For example, the geotechnical centrifuge sites might want self study background materials on sensor technology so that new researchers learn about best practices for instrumenting their models.

Another demonstration project, a series we will call *Inquiry Methods of Earthquake Science and Engineering,* will focus on specific learning challenges often experienced by graduate students as they begin a research project associated with using various facilities. For example, as part of a NEESR Project, a graduate student may need to become familiar with several fundamental concepts related to sensors and hybrid simulation. A PI could take the time to teach these concepts to each new graduate student, or the student could review the online modules to learn more about the concepts and then engage in productive conversations with the PI about the actual research goals and experimental methods. The EOT development team will work with NEES researchers representing diverse educational environments to generate a portfolio of learning modules that address concepts common to many research projects. One such module will provide a general introduction to the basics of performance-based design, which will involve a challenge-based instructional module that will embed video and NEEShub simulation resources. Each year NEES EOT will develop new modules and expand the portfolio for graduate student learning. Through an annual EOT workshop designed to build a large community dedicated to earthquake engineering education, NEES EOT recruit experts who teach at the university level to generate content and will work with these experts to refine content and author it into learning modules using CAPE. The NEEShub data repository represents a rich set

of performance data to compare with theoretical response. NEES Academy modules will be developed that allow the exploration of modeling assumptions and limitations in a variety of core undergraduate engineering courses such as concrete design, steel design, soil mechanics, and structural analysis.

As a form of assessment as well as community input into future development, the ratings and citation capability of NEEShub will allow the NEES community to judge the quality of an educational posting. Combining community feedback with usage statistics will inform ranking of resources. Furthermore NEES Academy will allow users to post citations that reference an educational resource in literature so that the community can readily find work built on that resource.

Conclusion

Using technology to provide learning resources has huge potential, especially as technology becomes more flexible and ubiquitous. The George E. Brown, Jr. Network for Earthquake Engineering Simulation is taking advantage of this rapidly developing technology to deliver education and outreach to a broad set of constituents. The HUBZero™ architecture provides the NEES community with cyberinfrastructure that includes tools for supporting collaboration and research. This architecture can also manage the archiving, searching, and accessing of a wide variety of web-based resources. The NEES Academy will leverage this potential along with the energy of the NEES community to design and deliver a powerful set of resources for learning at a variety of levels. Currently, the EOT development team is developing several demonstration projects to illustrate the NEES Academy potential and conduct research on learning with these materials. Future collaborations with others in the NEES community will expand the potential for resource development and learning with technology.

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