Curriculum Exchange: "Make Your Own Earthquake"

Dr. Sandra Hull Seale, UCSB

Dr. Seale earned the B.S.E. in Civil Engineering from Princeton University in 1981, the S.M. in Civil Engineering from MIT in 1983, and the Ph.D. in Civil Engineering from MIT in 1985. Dr. Seale is currently working as the Project Scientist and Outreach Coordinator for the Seismology Research Laboratory at UC Santa Barbara.

Dr. Thalia Anagnos, San Jose State University

Dr. Thalia Anagnos is a professor in the General Engineering Department at San Jose State University, where she has taught since 1984. She also serves as the co-Leader of Education, Outreach, and Training for the George E. Brown, Jr. Network for Earthquake Engineering Simulation. Her research interests are in structural engineering, earthquake loss estimation and risk analysis, engineering education, and informal education.

Dr. Lelli Van Den Einde, University of California, San Diego

Dr. Lelli Van Den Einde is a faculty lecturer (LPSOE) in the Department of Structural Engineering at UC San Diego's Jacobs School of Engineering. Dr. Van Den Einde's interest in teaching has influenced her current research efforts towards improving engineering education pedagogy through the use of technology in the classroom. She is involved in promoting academic integrity as a way to prepare our students to be ethical practicing engineers, and is the chair of the External Advisory Committee for the IDEA center, which promotes inclusion, diversity, excellence and advancement in engineering. She has conducted research in performance-based earthquake engineering and large-scale experimentation of reinforced concrete, FRP composite, and hybrid bridges.

Curriculum Exchange: “Make Your Own Earthquake”

Introduction

The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) is an NSF-funded research center focused on large-scale earthquake engineering research. The mission of the 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 large-scale equipment sites connected by an advanced cyberinfrastructure that enables rapid data viewing and analysis, data archiving, remote viewing and participation, and the ability to run interconnected experiments using several laboratory sites¹.

Each of the consortium research sites participates in outreach and education activities for the local schools and the public. The NEES research site at UC Santa Barbara, which operates earthquake field sites, designed a K-12 activity called “Make Your Own Earthquake” (MYOE). MYOE involves setting up earthquake field equipment (seismic instruments, data loggers, and computers) in a classroom. Children jump for 10 seconds, see their earthquake trace live on a computer screen and then take home a printed copy of their personal earthquake. Software was developed specifically for this activity. MYOE, which is aligned with state science curriculum, is used as part of a presentation on plate tectonics and seismicity and also as a station in a science fair.

Motivations and Goals

Having K-12 students make their own earthquake offers an opportunity to introduce some basic concepts in physics (motion and vibrations) and earthquake safety. The “big ideas” that this activity presents are tailored for different audiences. These topics include:

Ground Motion

- How are earthquakes generated?
- What kinds of waves are produced by an earthquake?
- How do we measure ground motion?
- What impact does soil type have on earthquake waves?
- How are earthquake magnitude and intensity different?

Building Vibrations

- How do buildings vibrate in an earthquake?
- What is the fundamental period of a building?
- What is resonance?
- What is base isolation?

For K-6 students, specific concepts are addressed:

- Why are there 3 components of motion in a seismogram? We live in a 3D world.
- What is acceleration? A comparison is made to gravity.

- Why do we experience earthquakes when they happen far away? Energy is released by the earthquake and travels in waves.
- Why do buildings shake in an earthquake? Buildings are excited by the ground motion, particularly if the ground motion has a period near that of the fundamental period of the building.

The California state framework now includes earth science for the 6th grade (until recently, earth science was taught by junior high school teachers). What students' learn is very dependent on their classroom teachers, yet 6th grade teachers typically have a multiple subject credential and may never have taken a course in earth science themselves. Thus, outreach of this type has become an important part of the classroom experience in California.

Description of Activity

In this activity, students (and their families) engage with earthquake practitioners and explore topics of acceleration, ground motion, building vibrations, geology, and tectonics. Students really enjoy their physical participation in MYOE and often ask to repeat their “earthquake”.

Originally the outreach activity was developed on expensive field equipment used for research at the NEES@UCBS site. Laboratory staff and students took research-quality accelerometers and data acquisition instruments to the schools to measure the “earthquakes” generated by the students. Not only was the equipment expensive, but it was also bulky and time consuming to set up. Two years ago, a new device became available that made MYOE portable and easy to use. A new MEMS accelerometer with a USB port can plug into any laptop computer. The device, shown in Figure 1 and developed by the Quake-Catcher Network (QCN)², is small, lightweight, and inexpensive (around \$50). MYOE software is free and downloads easily from the internet. Through outreach efforts, many more teachers and schools are able to run MYOE on their own.

Figure 1. The QCN USB sensor, available from <http://qcn.stanford.edu/sensor/>

MYOE engages the participants in earthquake science by having them simulate an “earthquake” by jumping for 10 seconds. The QCN sensor records the earthquake and displays it on the screen, which is visible to the person jumping (Figure 2). Software to display the vertical component of acceleration (a single trace) is available at this web address:

<http://nees.org/resources/myoe>. A video showing set up of the QCN is available at <http://nees.org/resources/2485>.

Figure 2. Display of single trace acceleration during “Make Your Own Earthquake”.

While students are participating in MYOE, they are guided by these sample inquiry questions:

- What happens when you jump with regular timing?
- What happens when you drum with your feet quickly?
- What happens when several students jump in unison?
- What happens if each student in a group jumps independently?
- What happens if you jump on a bouncy floor versus a hard floor?
- Can you point out in the record examples of fast versus slow jumping?

Sites Where MYOE is Used

With the introduction of the new sensor, NEES research laboratories have developed sophisticated activities for Make Your own Earthquake that align with California state science standards. The NEES consortium shares educational materials through NEESAcademy³, a centralized repository for earthquake engineering education and outreach materials, and K-12 teaching modules are available to the public at <https://nees.org/education/for-teachers/make-your-own-earthquake>. Specific examples of MYOE activities are presented below:

1. At the NEES laboratory at UC Berkeley, local elementary students tour the laboratory to learn about experimental specimens and large-scale laboratory test equipment. They participate in MYOE and build small structures out of K’NEX (Figure 3). These structures are placed on a table-top shake table and tested. NEES@Berkeley also takes MYOE to the local school district-wide science fair.

Figure 3. Students participating in MYOE after a lab tour.

2. At the NEES facility at UC Santa Barbara, MYOE is used in two different ways. The research group takes it to local elementary school science fairs, where students of all ages and their families are able to participate. NEES@UCSB also does formal presentations to 6th-grade classes in the community. A slide show and videos on plate tectonics and seismology (available at <http://nees.org/resources/2769>) introduce important science concepts. Individual students then participate in MYOE. The demonstration concludes with an earthquake generated by the whole class jumping at the same time, where students learn about “Band-Limited-White-Noise” (Figure 4).

Figure 4. A 6th-grade class in California demonstrates “Band-Limited-White-Noise”.

3. The NEES facility at University of Illinois Urbana-Champaign, couples MYOE with a presentation on earthquakes and inquiry-based activities. The students shake model

structures of different heights to see which is the “safest” and to observe vibrations and bending in the buildings (Figure 5). A video produced by NEES@Illinois shows how MYOE is used for large outreach activities⁴.

Figure 5. Students shake model buildings with different fundamental periods.

4. At the NEES site at UC San Diego, over 500 students a year participate in MYOE and a K-NEX building design competition. Undergraduate students from the university visit the various 6th grade classrooms to teach about earthquakes and basic concepts in structural design. The students are provided with K-NEX kits and are tasked to build structures to certain specifications including cost parameters. The students are also required to create structural drawings and architectural renderings. Students then visit the campus where they tour the earthquake engineering experimental laboratory facilities, participate in the MYOE activity, and culminate in a K-NEX competition to see how their structures perform (Figure 6). The inquiry-based activities include the examination of how shear walls resist earthquake forces.

Figure 6. Students in California shaking their K'NEX buildings.

5. The University of Nevada Reno research site has designed a version of MYOE that is a stand-alone exhibit installed at the Terry Lee Wells Museum. The installation, shown below in Figure 7, includes an instrumented permanent platform for jumping and a touch screen monitor for displaying the earthquake.

Figure 7. Permanent installation of Make Your Own Earthquake at the Terry Lee Wells Museum in Reno, Nevada.

Other Example Applications (for older students)

Learning activities geared towards older students have been developed by independent research organizations such as the Incorporated Research Institutions for Seismology (IRIS) and are available at <http://nees.org/resources/2807>. These include an exploration of magnitude and intensity of an earthquake targeting the following concepts:

- Does the amount of energy released change as the source is moved horizontally?
- How does the amplitude recorded by the sensor change as the source is moved farther away?
- How could the experiment be modified to increase the recorded amplitude at each position?

A schematic view of the system is shown in Figure 8.

Figure 8. Schematic view of QCN setup using MYOE to measure magnitude and intensity⁷.

Suggested Assessments

When appropriate, each NEES research site conducts assessments of student's interest/engagement and learning, and surveys of teachers providing input on how to improve the activities. Sample assessments are found at <http://nees.org/education/assessment-and-evaluation/surveys>. For a 6th-grade presentation, the students are presented with an assessment before and after the earthquake lesson and the MYOE activity.

Curriculum Exchange

In the curriculum exchange, we will demonstrate Make Your Own Earthquake on a laptop computer, exhibit videos of the new museum installation and other MYOE activities, and provide links to where the resources can be downloaded.

Acknowledgement

This work was partially funded by the National Science Foundation (NSF) through the George E. Brown, Jr. Network for Earthquake Engineering Simulation (CMMI-0927178). The findings,

statements and opinions presented in this paper are those of the authors and do not necessarily represent those of the NSF.

References

1. *NEES Overview*. (2013). Retrieved March 15, 2013, from the NEES web site: <http://nees.org/aboutnees/overview>
2. Quake-Catcher Network <http://qcn.stanford.edu/>
3. Brophy, S., Lambert, J. & Anagnos, T. (2011). NEESacademy: Cyber-enabled Learning Experiences for K-16 Earthquake Engineering and Science Education, *Proc. 41st ASEE/IEEE Frontiers in Education Conf.*, Rapid City, South Dakota.
4. Pluta, G., NEES EOT (2011), *Make Your Own Earthquake: NEES@Illinois*, <http://nees.org/resources/2988>.
5. Van Den Einde, L. (2012), "NEES@UCSD/COSMOS High School Earthquake Engineering EOT Activities," <http://nees.org/resources/5366>.
6. Incorporated Research Institutions for Seismology (n.d.). *How are magnitude and intensity different (yet related)?* Retrieved December 2, 2012 from http://www.iris.edu/hq/resource/magnitude_intensity