FINAL TECHNICAL REPORT

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Our Seismic Earth: An Interactive Module for Earth Science and Earthquake Education
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Final Report USGS/NEHRP, Award Number 03HQGR0109, ***Our Seismic Earth: An Interactive Module for Earth Science and Earthquake Education***

Abstract

Many efforts by Earth Science researchers to more effectively incorporate seismology, earth science, and earthquake awareness into K-12 classroom activities. These efforts have been hampered by a lack of modular interactive demonstrations and accompanying lesson plans that allow educators to quickly cover complex topics in cost effective and interesting ways. This is especially true in underserved communities, such as Memphis, TN, where standardized K-12 earth science scores are chronically low, many school buildings were not constructed to any seismic code, and populations are at risk from earthquakes. "Our Seismic Earth: An Interactive Module for Earth Science and Earthquake Education" (OSE) was developed to address these needs. OSE lesson plans were adapted to address specific concepts included in the state standardized testing system to support K-12 science teachers that are constantly searching for effective ways to improve science test scores. OSE is a portable system of interactive displays and related lesson plans to address plate tectonics, seismology, earthquake engineering, regional earthquake hazards, earthquake preparedness in the classroom, and general earth science. Teachers are also free to utilize tools in the OSE module, such as the oscilloscope, to demonstrate concepts from other scientific disciplines. The project benefited from over 30 years of K-12 Earth Science and earthquake awareness education programs and partnerships at the Center for Earthquake Research and Information (CERI). Four OSE modules were developed and are used by K-12 teachers and CERI Education and Outreach staff on a regular basis.

Report

CERI Education and Outreach staff address thousands of K-12 teachers and students every year, but we are constantly searching for new methods and tools to effectively reach larger audiences in partnership with NEHRP and the US Geological Survey. Our Seismic Earth (OSE) is a project designed to provide new interactive educational tools with associated lesson plans to increase earthquake hazard and Earth Science awareness in the Central US. A major advantage of the OSE system is that it allows K-12 teachers to present USGS/NEHRP education material in class without direct interaction from scientists. Considering that relatively few scientists are available to present to K-12 classrooms on a frequent basis, this approach allows NEHRP and other scientific organizations to distribute standardized information in an interesting and effective manner to a larger portion of at-risk populations. The tools and lesson plans developed for this project are a direct result of over 3 decades of outreach experience achieved through CERI's partnership with the USGS. The OES teaching module utilizes NEHRP map products, USGS scientific information on plate tectonics and related materials. As a result of this project, we have learned that interactive K-12 classroom lesson plans must be easily understood, associated interactive displays must be durable and safe, and the program should not require a significant amount of preparation time on the part of the teacher. Class activities were developed to address national standards for teaching in learning to promote higher achievement on standardized K-12 earth science tests. OSE has successfully met these needs by developing a robust, easy–to-use teaching module that emphasizes the need to reduce losses from future earthquakes and directly addresses information that teachers are required to teach.

OSE Components:

Figure 1. The OSE portable learning modules (4) for earth science and earthquake education consists of a durable carry case with wheels, shake table, modified doll house with furnishings and fixtures, lava lamp, earth structure model, silly putty, oscilloscope, geophone, and associated lesson plans.

Each modular container in Figure 1 contains a complete OSE system and weighs 75 pounds. Most of the weight is due to the shake table (50 lbs.) and oscilloscope (12 lbs.). The cases were selected for durability, weather resistance, and transportability. Each container can also be secured by using a simple combination lock. Oscilloscopes are packed in Styrofoam fittings provided with each case.

OSE Shake Table

Figure 2. OSE shake table.

One of the major needs of this project was to develop a high quality demonstration shake table this is safe, portable, and durable. CERI has been designing and building its own informal educational shake tables since 1982. As a result of this institutional knowledge, we know that demonstration-grade shake tables must be made with quality materials; without pinch points; and provide frequency and displacement ranges that are necessary to accurately demonstrate the effects of large and small earthquakes on various objects and structures. Specifically, we wanted to demonstrate magnitude and intensity relationships, and structural and nonstructural hazards. High quality gears and motors were utilized to limit electrical and mechanical failure that could occur in a classroom setting.

Commercially available educational shake tables are often driven by a commercial orbital sander with variable speed control. These systems have very low displacement (<0.25"), operate efficiently at high frequency (15-40 Hertz) and are not designed to run at low frequency for long periods of time. The OSE shake table design is the result of 30 years of experimentation and testing through CERI's E and O program to provide optimum safety, weight, frequency, and displacements. The total displacement of is 2" with a frequency range of 1 – 6 Hertz. The maximum displacement was limited to eliminate any open pinch points as the table oscillates but still accommodates a wide range of demonstration applications. CERI technical staff, Greg and David Steiner, were responsible for the design and production of the 4 OSE shake tables. The removable top is composed of cushioned fiber mounted on plywood. The fiber allows the use of Velcro to couple objects of various sizes and weights to the table. The padded backing provides some dampening to eliminate a completely rigid response. Several padding materials with differing characteristics were tested to arrive at a product that enhances the simulation. The bottom of each shake table was covered with neoprene to provide coupling with smooth surfaces.

OSE Dollhouse

Figure 3. OSE dollhouse, second floor detail.

OSE houses include working cabinet doors, ceiling fans, and other elements to demonstrate magnitude-intensity relationships, as well as non-structural falling hazards. Many commercially available dollhouses were investigated but none met project specifications (270* viewing, modular, adequate coupling between floors, etc). One model was selected and modified to meet these needs. Three sides of each floor module replaced with transparent acrylic sheets to provide 270* viewing. Velcro strips were added to provide fast and adequate coupling with the shake table.

OSE Oscilloscope and Geophone

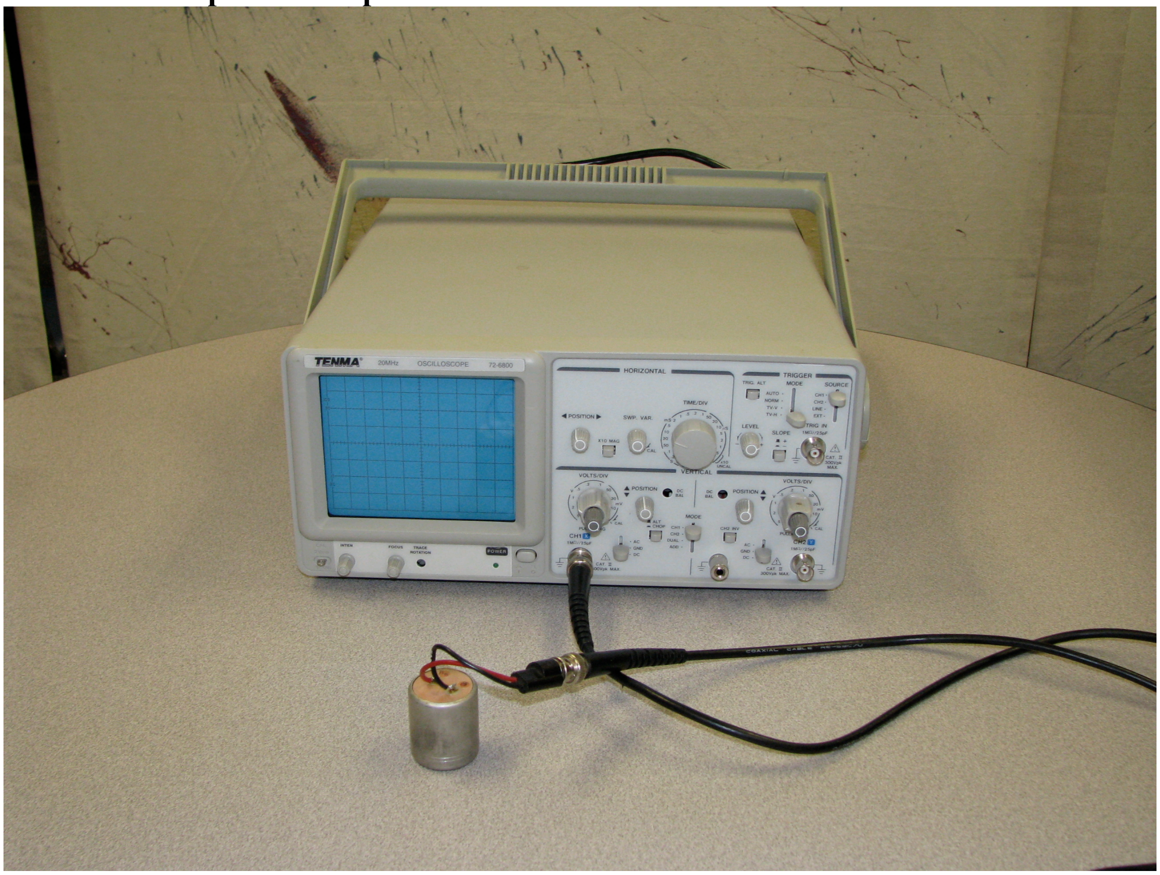

Figure 4. OSE oscilloscope and geophone to "Make your Own Quake."

One of the most interesting aspects of this project was to provide high quality oscilloscopes for teachers to create and display local vibration sources. "Make your own quake," allows a student to understand the link between wave amplitude and source energy. Placing the geophone on different materials (tables versus the floor) while keeping the source at a constant distance allows for a quick understanding of path and site effects. Several of the teachers who utilize OSE in their annual teaching activities have developed other uses for the oscilloscope to understand the characteristics of sound waves. These teachers have come to depend on the use of OSE on an annual basis as part of their teaching plan. A **slinky** is also included in these lesson plans to demonstrate P and S wave propagation.

OSE Earth Structure Components (shown in Fig. 1)

The OSE system also includes a 12" earth **structure model** composed of durable rubber that can be taken apart to reveal the layered interior of the earth and support discussions on the driving forces of plate tectonics. The model is large enough to be shown to a classroom and durable enough to be handled freely by students without fear of damage or injury. While the use of high quality plate globes would be preferable, none were found that were durable enough to be used in the OSE system. A **lava lamp** is also included to demonstrate mantle convection. **Silly Putty** is included to demonstrate material properties of the mantle.

OSE Lesson Plans

OSE lesson plans were developed in collaboration with former high school teacher and project Co-PI, Michelle Dry. Ms. Dry's teaching experience allowed us to modify our existing programs and lesson plans to address specific elements of the Tennessee Standards for Teaching and Learning.

Activity:
1. What's inside the earth?
2. How's the Earth Like a Jigsaw Puzzle?
3. How and why do the plates move?
4. Where do earthquakes occur?
5. What does pressure (energy build up) have to do with earthquakes?
6. What is the New Madrid seismic zone?
7. What do earthquakes tell us about the earth's interior?
8. How does and earthquake wave move?
9. Do earthquakes always cause damage?
10 Why are earthquakes felt in some places but not others?
11. How can I make my own earthquake?
12 Oscilloscope settings (step by step instructions)
13. How does the ground liquefy during an earthquake?
14. How and why are building codes developed? (Hazard map discussion)
A1. Internet resources
A2. Careers in Earth Science and Seismology
A3. Tennessee Science Curriculum Standards (K-12)

These lesson plans can be accessed through the project PI, Gary Patterson, glpttrsn@memphis.edu

Project Status
The OSE project remains an important part of CERI/USGS Outreach program. Four OSE modules are permanently stored at CERI and are distributed upon request. Some teachers in Memphis, Tennessee utilize OSE systems on an annual basis as a dedicated part of their earth science/physics curriculum. The use of OSE modules by teachers is promoted in CERI K-12 presentations and workshops. Teachers from Kentucky, Tennessee, and Arkansas have used the OSE module, although the weight (150 lbs.) and size of the module ((24" by 48" case) make it rather costly to ship. Teachers in Puerto Rico requested the use of OSE modules through the Department of Geology of the University of Puerto Rico in Mayaguez, but shipping fees were too expensive. One of the OSE modules is currently in use (7/20/10- 9/20/10) by the William J. Clinton Presidential Center Library in Little Rock, AR. The Center is utilizing an OSE module to provide

interactive tools to support their current "Nature's Fury' exhibit, which has bee seen by over 40,000 visitors in 2010.

CERI is currently developing the OSE module to better support New Madrid Bicentennial, National Level Exercise, and EarthScope activities. The interactive elements will remain unchanged except for the addition of a log home to be used on the shake table. OSE lesson plans are being modified to relate specifically to the range of felt effects across the eastern US documented during the winter of 1811-12, and to reflect the importance of broadband seismology and seismic networks in areas of significant earthquake risk.

Results and Conclusions

OSE provides standards-based class activities that utilize interactive displays to increase awareness of earthquake hazards, earth science, and some basic earthquake engineering concepts. Science teachers in urban settings that are at risk from large earthquakes are always interested in classroom safety, however, that are also very interested in getting better scores on standardized Earth Science achievement tests. Many science teachers are in a constant struggle with low student achievement and are constantly looking for better ways to grab the student's attention. The OSE project team learned that we could make relatively minor changes to our educational information and have a potentially significant impact on the student's performance on standardized tests. For instance, 7th grade science textbooks discuss transverse and compressional waves in detail, but provide little, if any, discussion on P-waves and S-waves. By simply modifying the nomenclature used in academic settings, we increase the likelihood of better student scores on standardized science tests.

Although OSE was originally targeted for K-12 teachers and students, it became obvious that most interest was from teachers and students in grades 4-8, which is the level at which children begin to learn about science. It also became obvious throughout the course of this project that many middle schools science teachers, especially those in underserved communities, have minimal or no earth science background, and some struggle to understand the basic concepts of seismology. OSE provides these teachers with free interactive tools to address these concepts in a way that holds the attention of the student. The OSE team never fully achieved its goal of becoming a regular tool for teachers in underserved areas in Memphis. Although the lesson plans and displays had been simplified through several revisions, many teachers do not have the time or knowledge base to integrate OSE into their curriculum. Some were intimidated by the equipment (oscilloscope) while others were concerned about theft or breakage.

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Related Publications: None