TEACHING SCHOOL SAFETY AND ADVOCACY IN THE CLASSROOM

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ABSTRACT

One of the goals of the Earthquake Engineering Research Institute’s (EERI) School Earthquake Safety Initiative (SESI) is to develop and conduct regionally appropriate education efforts to make a tangible and positive difference in communities. This includes the development of well-defined, quality lesson plans and teaching tools to engage local classrooms in learning about earthquake engineering. This paper introduces the SESI curriculum and how SESI approaches and templates can be utilized for outreach efforts. The paper highlights several pilot programs implemented by the University of California, Berkeley, Stanford University, and the University of Washington. K-12 students from across the United States have received classroom lessons or outreach activities through these pilot programs, including activities targeting under-represented minorities. Lessons-learned from experiences in community engagement using the SESI curricula is described with the goal of encouraging ongoing and future efforts to expand these programs to the EERI professional community and other universities.

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Introduction

The Earthquake Engineering Research Institute (EERI) is a multi-disciplinary national society of engineers, geoscientists, architects, planners, public officials, and social scientists; including researchers, practicing professionals, educators, government officials, and building code regulators. Its mission is dedicated to advancing the science of practice of earthquake engineering and reducing the impacts of earthquakes on society. EERI’s School Earthquake Safety Initiative (SESI) aims to engage the EERI membership in a global and collaborative network of diverse and expert professionals committed to school earthquake safety. The focus of this effort was on regionally appropriate actions to make a tangible and positive difference in communities. SESI is led by an executive committee that coordinates the work of five sub-committees: 1) Safety Screening, Inventory, and Evaluation of Schools, 2) Classroom Education and Outreach, 3) Tsunami Mitigation for Schools, 4) Code Updating and Improvements, 5) Safety Advocacy and Messaging.

This paper highlights the efforts of the Classroom Education and Outreach sub-committee, including best practices on how to utilize SESI approaches and templates to advocate for improved school earthquake safety in communities across the country. The paper also describes the community engagement recommended by other efforts to promote disaster resiliency of schools such as FEMA P-1000. The ultimate goal is to teach school children and teachers about earthquake engineering and school seismic safety using a program that can be easily adopted by other communities both nationally and internationally.

FEMA P1000 Outreach

In order to improve resilience of our nation’s schools against disasters such as earthquakes, communities must be engaged in the process to understand and reduce school risks, plan for emergencies, and recover from damaging events. The Federal Emergency Management Agency (FEMA) has developed a guide (FEMA P-1000, [1]) that provides up-to-date, authoritative information and guidance schools can use to develop a comprehensive strategy for addressing natural hazards and providing safe and disaster-resistant schools for all. FEMA P-1000 emphasizes engaging not only key stakeholders such as design professionals, educational professionals, elected officials, and emergency management professionals in the preparedness and mitigation planning for school natural hazard safety, but also involving other community members such as children and youth, parents, caregivers and local community organizations to learn about ways to advocate for safe schools in their communities. FEMA P1000 states that engaging the whole community requires understanding and meeting the community’s needs, engaging and empowering all parts of the community, and strengthening what already works well in communities on a daily basis.

EERI School Earthquake Safety Initiative

The School Earthquake Safety Initiative (SESI) is a global and collaborative network of diverse, expert, and passionate professionals committed to creating and sharing knowledge and tools that enable progressive, informed decision making around school earthquake safety ([2] and [3]). SESI’s vision is to serve the world as a leader in the science, public policy, and advocacy of school earthquake safety. It is an initiative of the Earthquake Engineering Research Institute (EERI). SESI serves stakeholders in school earthquake safety, from children and their parents, to teachers and
administrators; from developers and architects, to engineers and builders; from financial institutions and building officials, to government agencies and emergency managers; from civil servants and commissioners, to local politicians and state and federal legislators. EERI leverages its extensive expertise and reputation to conduct regionally appropriate actions that make a tangible and positive difference in communities around the world, by protecting the lives of all who inhabit school buildings.

SESI is an effort primarily conducted by volunteers. Thus, early in its establishment, a focused and narrowed scope was created to target activities and actions into achievable areas where change is most possible with a reasonable assessment of volunteer time. The initial focus of SESI is on school buildings in the US, but the network hopes to expand in future years to have impact internationally. The SESI scope is currently defined by the following principles that the initiative will continue to build upon and revise as this effort grows and matures:

1. Earthquake and earthquake related hazards (shaking, tsunami, liquefaction, landslides, etc.) will be the primary hazards addressed in this Initiative.
2. While all schools are important, efforts will be focused on schools in high and moderate seismic hazard regions and for events that have a higher probability of occurrence.
3. Schools will be broadly defined to include public, parochial, charter, state, and private schools from pre-kindergarten through university level, however the initial focus will be on K-12 public schools.
4. The stakeholders engaged will depend on the activities of each subcommittee, however the initial focus will be on knowledge transfer and outreach to: state agencies, school administrators, code development committees, legislators, teachers, students, and parents.
5. EERI’s SESI advocates for mitigation of earthquake risk to children in existing schools via building retrofit, abandonment, or replacement, as well as nonstructural retrofit.

School Classroom Education and Outreach

The Classroom Education and Outreach Subcommittee is tackling the problem of school safety from a grassroots approach, with the goal of using education in the classroom to create ongoing dialog with parents, teachers, and administrators thereby developing advocates for earthquake school safety. As has been demonstrated with the Great Southern California ShakeOut and the Dare to Prepare campaign, consistent and simple messaging is an effective way to help the public understand how to be safe in an earthquake and to take action to prepare for future events [4]. The SESI Classroom and Outreach Subcommittee is using a similar approach to help students, teachers, administrators, and parents become aware of the seismic risks in their schools. In order to meet the goals of the subcommittee, EERI regional and student chapters are brought together to collaborate on delivering the educational activities to K-12 students across the country and internationally.

K-12 engineering curriculum aligned with standards that come with well-defined documentation and can be easily taught to a range of teachers for broad dissemination have been developed for 4th grade and high school physics classes. Both the 4th grade and high school curricula lead students through hands-on and research activities to learn basic earthquake engineering design principles such as the effects of earthquake-resisting elements like diagonal bracing and shear walls. They make use of an electronic instructional shaking table that tests structures under representative earthquake loading. The 4th grade project requires students to build K'Nex™ buildings, while the high school physics project consists of two-story balsa wood structures and integrates
mathematical predictions into a design competition. Both curricula have been related to numerous California State Standards and Next Generation Science Standards (NGSS) [5] in the area of earth sciences, mathematics, and engineering design. Details of the curriculum can be found in [3].

Student outcomes for both curricula are similar. Upon completion of the projects, students will learn that earthquakes are a natural hazard and engineers help design buildings to reduce damage; discover what building elements affect building stability; generate and compare multiple solutions to enable a model building to resist shaking; understand that study of failure mechanisms can be used to improve design; experience the engineering design process, including defining design problems, using fair tests to collaboratively produce data; compare alternate solutions with design criteria; and communicate evidence-based recommendations.

Implementation of outreach depends on the following three-tiered objectives:

1. **Earthquake safety** - making connections with schools to aid in future efforts; incorporate earthquake science and safety topics
2. **Education standard** - giving schools immediate benefit; satisfy latest education standards including Next Generation Science Standards [5], and other national/state curriculum standards; complete curriculum in 2-4 visits.
3. **Engineering principles** - developing exciting, hands-on, project-based engineering curriculum; using shake table technology to aid instruction

Achievement of these objectives relies on the development of well-defined, quality standards-based lessons, including material lists, description of activity’s alignment to educational standards, lesson plans, supporting materials (PowerPoint files, posters, handouts, etc.), and assessment tools [7]. The following strategy has been implemented to promote the implementation of SESI outreach programs:

1. Select one K-8 and one High School activity and assemble it into a lesson plan with appropriate documentation.
2. Collaborate with Advocacy Subcommittee, Screening Subcommittee, and Executive Committee to develop messaging to share with teachers, parents, and administrators.
3. Recruit and select final pilot groups and schools.
4. Create training materials.
5. Host training workshops in pilot regions.
6. Support pilot launch to local schools.

Several pilot programs have been initiated to test out the curriculum and the implementation model on 4th grade and high school students. These pilot programs seek to engage EERI professionals and/or student chapters in local outreach programs and activities. Details of these pilots and lessons learned are provided in the following section.

**Pilot Projects**

The goal of the pilot programs was to make use of the EERI student and professional regional chapter membership to complete lesson delivery to local schools. This section focuses on pilot programs implemented by the University of California, Berkeley, Stanford University, and the University of Washington, which were initiated to generate volunteer recruitment and build
relationships between EERI professional and student chapters, and the local schools they are servicing.

**Berkeley Pilot Study**
The pilot program at Berkeley leveraged a two-day curriculum developed at UC Berkeley as part of a the National Science Foundation (NSF) Network for Earthquake Engineering Simulation (NEES) education and outreach program. The NGSS aligned curriculum was guided by an educational curriculum specialist from a local non-profit group on appropriate vocabulary, supplemental worksheets, and delivery strategies to optimize implementation in the classroom.

The pilot study began under the local Berkeley EERI chapter in December of 2015. Instruction has focused on outreach to local 4th grade classrooms in Oakland, CA. The two 90-minute lesson plans depend on two visits, usually on consecutive weeks. The first visit introduces the students to earthquakes, the engineering process, and design elements. The lesson plan allows students to test concepts related to the strengthening and testing of buildings. The intention of the first lesson is to provide sufficient vocabulary and visual demonstrations to help students develop the means of designing their own earthquake-resistant buildings during the second visit. During the second visit, the students use their knowledge base to participate in an earthquake design challenge. The students are engaged in a defined design problem where they can develop a model and testing plan, test alternate ideas, analyze data and discuss solutions, and communicate design solutions. Both lesson plans depend on K’Nex building kits, individual manual shake tables, and an electronic shake table.

A roadmap that summarizes implementation best practices based on the 2015-2016 SESI pilot at UC Berkeley is provided below. This roadmap worked well for a semester based-system where most of the volunteers were Structural Engineering, Mechanics, and Materials (SEMM) masters students (2-3 semesters) and 2-3 Ph.D. students (continuing).

- **April** - Advertise during Civil Grad Student Open House.
- **August** - Advertise during Fall Semester Week 0 welcome / meet and greet for incoming graduate students
- **September** - Recruit through the SEMM graduate student adviser by email as a call for SESI volunteers
- **October** - Promote through Cal SEAONC and EERI as a call for SESI volunteers
- **November** - Round up volunteers, classroom training, and prep of the new volunteers
- **December** - Have the first two 90-min. classroom lessons during dead week
- **January-May** - Ongoing classroom visits

The ongoing visits are best implemented through rotating volunteers so that students do not have to volunteer more than two days out of the month. Interest in this pilot program has been consistent since it was implemented in 2015. However, the apprenticeship program from year-to-year relies on continuing Ph.D. students.

The following are suggestions for improvement:
- Continuity plan for EERI student groups (including resources and contacts) for sustainability of program if EERI student chapter members are graduating/unable to continue participation in SESI program.
• Link the SESI program with the EERI student chapter activities like the EERI Cal Seismic Team to keep the continuity of leadership and volunteers for the SESI program, especially for those who stay for the graduate program.
• Formation of a small subcommittee to work on a best practices document for the outreach which includes how to find and schedule schools.
• Creation of curriculum “options” for different events with time restrictions (e.g., 1-hour curriculum, multiple hour curriculum, several day curriculum, etc.).

Stanford Pilot Study

The Stanford SESI education and outreach pilot study was conducted in May of 2017 at Sequoia High School to students enrolled in AP Physics. The goal of the program was to: (1) teach the basics of earthquake engineering using mathematical and physics first principles and (2) demonstrate the applications to seismic design using hands-on applications. An experimental test of a two-story balsa wood structure was used to demonstrate the applications of seismic design. The lessons were condensed to one week due to the availability of the students. The lesson plan was divided into three lectures along with an experimental test. Below is a day by day account of the lesson plan and activities:

• Day 1 (May 22nd, 2017): Lecture 1, 40 mins
  The first lecture reviewed the concepts of forces and equilibrium and introduced engineering seismology, seismic waves and potential consequences of earthquakes.

• Day 2 (May 24th, 2017): Lecture 2 and experimental setup, 90 mins
  The second lecture focused on load paths and earthquake-resistant structural systems. During this lecture, students were broken down into groups of five and given the materials (e.g., balsa wood, glue, cutting materials, etc.) for the project. The project consisted of building a two-story balsa wood structure using the earthquake-design methods (e.g., shear walls, braces, etc.) learned earlier.

• Day 3 (May 26th, 2017): Lecture 3 and shake-table testing, 90 mins
  Finally, the last lecture was dedicated to vibration analysis, resonance and dynamic behavior. In addition, the steps to pursue a career in structural engineering were laid out for interested students. For the second part of the class, students were given additional time to finish the lateral-resisting systems of their structure. The structures were tested using a shake-table reproducing recorded earthquakes.

In terms of the implementation details, the pilot group found that:

• Students in our program were genuinely enthusiastic about this opportunity
• There needs to be a direct link with a teacher or administrator at a local high school for successful implementation, and a graduate student in charge of the SESI programming coordinating with the high school
• Planning ahead of time (3 months) to coordinate high school and graduate student schedules is necessary (in our case we had to avoid AP Physics tests and midterms)
• Construction of the balsa wood archetype houses (before retrofits) took more time than necessary, this year we are considering building at least the diaphragms to speed up the process.

The Stanford SESI education and outreach program was a delightful experience for both the students and the instructors. The students learned some interesting applications of the physics theory they were currently enrolled in. In addition, a hands-on approach to engineering seismology demonstrated the importance of structural engineering and earthquake. Overall, the students were excited to complete their projects and enjoyed the shake-table test. Some of the challenges encountered were the time commitment from graduate students at Stanford as well as the time necessary to complete all lectures and build the balsa wood house prototypes. The Stanford EERI student chapter will be participating in the SESI program again this year with Sequoia High School.

**Washington Pilot Study**

In 2017, the EERI University of Washington Student Chapter (EERI/UW) and the Washington Geological Survey (WGS) coordinated two joint educational outreach events at elementary schools in Wenatchee School District in Central Washington. These efforts were part of a larger, WGS-led project to evaluate the seismic risk of school buildings in the region, and the participants’ presence in the region enabled a unique, two-day curriculum for third-to-fifth grade students that leaned on the expertise of WGS scientists and EERI/UW students.

At each school, approximately one hour of contact time was budgeted per class, and three to four classes were taught per day. The first day of instruction was organized by WGS to introduce plate tectonic theory, seismic wave propagation, and the effects of local soil conditions on ground motions. These concepts were reinforced through interactive demonstrations which utilized instrumentation (including a seismograph and geophone array) originally brought by WGS to characterize soil properties as part of the seismic risk assessment program. Students from EERI/UW led instruction on the second day using material adapted from the SESI earthquake engineering design lessons for fourth-grade students. Instruction was supplemented with visual media to show the effects of earthquakes on real buildings and how researchers test building response in the laboratory. Students were then tasked with designing, testing, and repairing/retrofitting their own earthquake-resistant structures using a portable shake table.

The collaborative approach to teaching from WGS and EERI/UW was effective in introducing and connecting a variety of earthquake engineering topics. Similar coordination between geological, geotechnical, and/or structural engineering experts is recommended for future outreach programs to help present a complete picture of the earthquake engineering landscape. In addition, it is noted that more than half of the students in Wenatchee School District identify as Hispanic/Latino. Language barriers must be recognized by classroom outreach participants, and the use of visual aids and hands-on activities proved central to the success of the curriculum undertaken in Central Washington. These methods engaged students with different learning styles and helped avoid potential language barriers by putting the students in the “driver’s seat” of their lesson.

**Industry Participation**
The university pilot programs have been supported by industry participants and members of EERI regional chapters. The EERI SESI outreach program encourages EERI Student Chapters to share their work through SESI to regional chapters, with intent of knowledge sharing and industry collaboration. Through EERI regional chapter meetings, students can “pitch” for member in-kind support in the classroom, receive suggestions for volunteer opportunities at schools that members' children attend, and achieve other forms of potential financial support. A SESI facilitator, who is ideally a board member of a regional chapter or an interested chapter member, may be helpful in initializing the relationship between the broader membership of EERI Regional Chapters and local student chapters. Students may also have the opportunity to raise awareness and solicit for in-kind or financial support through the regional chapter’s newsletter or other digital communication platform. Continuing students within the student chapter (PhD, Post-Doc) can maintain communication with board members for sustainability of future programs and should appoint a student chapter member that plans to remain committed to the SESI program through the duration or bulk of their time at the University to maintain a point of contact as the program develops.

Conclusions and Plans for Outreach

The curriculum developed as part of the SESI Classroom Education and Outreach committee has been successfully used at UC Berkeley and UC San Diego where they were originally developed. The pilot studies presented in this paper demonstrate that the curriculum could be adopted by other EERI chapters and implemented effectively. Lessons learned include the need for sustainable methods of recruiting and training student volunteers at the various EERI university student chapters. Funding is required to support the materials needed for the various outreach programs.

In addition to planning for sustainability within chapters, future plans for this outreach and education program include expanding the pilot programs to larger groups of university and regional EERI chapters such that the curriculum and the SESI message can be disseminated to a larger population. Additionally, the program needs to come up with a plan for funding to support supplies and materials as well as maintenance of the equipment. Finally, the sub-committee is always looking for ways to incorporate and develop new educational modules in other areas that pose risk to school safety such as tsunamis.

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References


