



Earthquake Engineering with K'NEX



Society of Civil and Structural Engineers

Founded in 2007 by the Society of Civil and Structural Engineers at UC San Diego, the *Earthquake Engineering with K'NEX Outreach Program* (more often referred to as *Seismic Outreach*) has served to educate 6th grade students in the greater San Diego County on the fundamentals of earthquakes and earthquake-safe structural design principles. Throughout the past 7 years, the program has brought an engaging, hands-on educational experience to over 7,000 6th grade students, spanning 5 school districts in San Diego County.

Today, the Seismic Outreach program is a self-sustaining, fully student-organized operation. Furthermore, because of the overwhelmingly positive feedback from the participating students and teachers,

the program now receives multiple requests from new schools seeking to participate each year. To meet increasing demand, the student leaders at UC San Diego are seeking ways to expand the project by involving other engineering schools in the Pacific Southwest region. We hope that you will take some time to learn about the program and consider partnering with us to establish this type of community outreach at other universities.

Goals

The goal of this project is to inspire young students to get excited about studying science, engineering, technology, and math (STEM) disciplines. We accomplish this goal by exposing 6th-grade students to the fundamentals of the engineering profession through a K'NEX-based design competition. It is our hope that the enthusiasm we see from the students will translate into increased enrollment in technical majors at 4-year universities.

UCSD Project Overview

The program is comprised of three phases. To begin, our volunteers visit each school to give in-class presentations. The sixth grade students are then given several weeks to design a high-rise K'NEX building and create the associated construction documents in their science classrooms. Finally, they come on a field trip to UCSD, where their structures are tested on a mini shake table and they have the opportunity to interact with college students on a college campus.

Phase 1: In Class Presentations

The in-class presentation is based on a PowerPoint presentation laying out some of the basic principles of earthquakes and seismic design. The topics of the presentation have been designed to integrate with the California sixth-grade curriculum standards on earthquakes. This allows the teachers to plan their curriculum in such a way that volunteers can reinforce the concepts that students have already learned.

During the presentation, visual aids, materials to be passed around, interactive demos, and videos all serve to engage the students in the topics being discussed. The sixth graders participate by answering questions





asked by the UCSD students. Typically, two to five UCSD students give the presentation over about an hour. An effort is always made to schedule at least one female UCSD volunteer to go to each in-class presentation in order to encourage female sixth graders to pursue engineering, as it is traditionally a male-dominated field.

The topics covered in the presentation include:

- Plate Tectonics, Fault Mechanism, Fault Types, P-Waves, S-Waves
- Famous Earthquakes, Earthquake Damage
- Earthquake Research: Shake Tables and Full Scale Structural Testing
- Forces: Tension, Compression, Torsion, Shear
- Beams, Columns, Bracing and Buckling
- Roles of and relationship between the owner, architect, engineer and contractor

Phase 2: Project Phase

The design challenge presented by the Seismic Outreach project is to design a model high-rise building for downtown San Diego. Since California is a region of high seismic activity, the owner of the building wants a seismically safe structure with maximum floor area, minimum building cost, and a pleasing architectural aesthetic.

Following the in-class presentations introducing the sixth graders to the project, several weeks are allotted for them to complete their structures and associated documents. Students work in

teams of four during their science instructional time over those weeks. Under the guidance of their teachers, students build and rebuild their K'NEX structures until they settle on a design. They then create construction drawings to scale, including floor plans and elevations of their structure, with dimensions. Each group also creates an architectural rendering depicting their concept in an attractive setting.

Phase 3: Field Trips

Finally, the sixth-grade students visit campus, usually one school per day over the period of a couple weeks. Upon arrival, the excited sixth graders (and their teachers and parent chaperones) are given a brief overview of what their day is going to be like. They are then split up into their classes and then sent to different stations around the school. There are four stations that each class rotates to throughout the day. Each station is described in the following sections.

- **UCSD Campus Tours** - Students are taken on a quick tour around the main UCSD campus, which mainly features the UCSD library, Dr. Seuss statue, and the engineering quads. The second half of the tour takes students to one of the active structural testing labs on campus. The sixth graders are told interesting facts about the lab and shown the projects that the lab is currently working on. They are also encouraged to ask the lab director any questions that they may have.



- **Games and Recreation** - sixth graders and UCSD students interact in a grassy quad, and play games like waffle ball or Frisbee. This allows the sixth graders to talk with UCSD volunteers on a personal level and learn about college life. It also allows the sixth graders to move around and relax, allowing them to feel comfortable in the new setting and to get rid of excess energy.



- **Judging and Interview** - The sixth graders are given a chance to present their model in their original team of four during the judging and interview section. They are given a few minutes to talk about their model to a UCSD student volunteer, and then they are asked a few questions on material covered over the in-class presentation.



- Mini Shake Table Earthquake Testing** - A mini shake table is provided by the UCSD Englekirk Center, a test facility of the Network for Earthquake Engineering Simulation (NEES). At this station, the K'NEX models are tested one by one. Weights in the form of washers are added to each structure to simulate the real weight of a building, and the buildings are shaken in a simulated earthquake. The sixth graders are usually never disappointed in the results, as the satisfaction of surviving the shake is just as satisfying as watching the destruction of the model.

At the end of the field trip, awards are presented to teams who did exceptionally well in certain areas. There are three awards, and each member of a winning team is given a high quality certificate and free movie tickets. The awards are the Contractor Award, the Architect Award, and the Structural Engineering Award. The Contractor Award is given to the team with the best combination of a high interview/presentation score and structural document score. The Architect Award is given to the team with the most creative and best-looking architectural rendering. The Structural Engineering Award is given to the team whose model survived the simulated earthquake shake and had the best performance index.

Project Impact

The Seismic Outreach project is the largest student-organized outreach program at UCSD, and quite possibly one of the largest in the nation. Over 7,000 students at 26 different schools



have participated to date, with 1,800 participating in the 2012-2013 year alone. Hundreds of UCSD students and dozens of industry professionals have volunteered their time to make a difference in the lives of these children. What kind of impact is being made by this effort?

Firstly, the project provides a memorable, educational, and fun experience for the sixth graders. Teachers have told us that the excitement of having college students visit the sixth-grade classrooms helps their pupils learn the material much better than classroom instruction alone. The kids often want to stay in class during their recess time in order to spend more time working on their projects.

It is our objective for this excitement about studying science and engineering to carry over into future schoolwork and eventually to participants' career decisions. The current shortage among U.S. students majoring in science, technology, engineering and mathematics (STEM) fields, especially relative to the demand for these skills in industry, has been well documented for many years. We are hoping, through this program, to encourage students to pursue those careers.



NUMBERS

5/26/7,000

San Diego school districts, schools, and students (estimated) that have participated to date.

75,000

Number of K'NEX pieces used.

21+

Combined number of companies, organizations, and professional societies involved in the program to date.



We also place a special emphasis on reaching economically disadvantaged school districts where many of the children might not otherwise consider college as an option. In interacting with the students, our volunteers serve as role models encouraging all the students to consider STEM careers.

Finally, our engineering student volunteers also benefit tremendously through their participation. The leadership team must learn planning and organization skills important to their career development. All of the volunteers improve their soft skills by communicating with the sixth graders, often having to teach technical topics at easily understandable levels. Developing the leadership, communication, and time management skills of our members are key objectives of our organization, and Seismic Outreach is helpful in accomplishing all of those goals.

Logistics

Volunteer Support

This program is primarily administered by the Society of Civil and Structural Engineers at UCSD, the student chapter of the American Society of Civil Engineers (ASCE) and the Structural

Engineers Association of San Diego (SEAOSD). It was founded by UCSD students and continues to be led by student volunteers. However, the flexible nature of the program allows UCSD college students from any major to volunteer. While some tasks require prior knowledge of earthquakes, most require none at all. Furthermore, training is available to all volunteers that wanted to participate in tasks such as controlling the shake table. Between ten and twenty student volunteers typically help with the in-class presentations, while between ten and fifty participate in the field trip portion of the project.

Of course, it would not be possible for the program to succeed without the support of many other organizations in the community. Generous support from K'NEX was key to launching the project. Many professional societies have been involved over the years, including ASCE, SEAOSD, the NEES, the American Institute of Architects (AIA), Women in Transportation Services (WTS), and others. Local engineering, architecture, and construction firms have also been instrumental, sending employees to volunteer for field trip events and making financial contributions that were critical to launching the program. Within

UCSD, other engineering organizations have also supported the project, most notably the Triton Engineering Student Council and the Jacobs School of Engineering through the IDEA Center.

In other words, while Seismic Outreach is primarily organized and executed by students, maintaining a collaborative relationship with other partners in the community was critical to launching the program. Moving forward, such collaborations only enrich the program further and open up more possibilities for it to be improved.

Materials & Budget

Starting a Seismic Outreach program is a substantial undertaking that requires significant financial support to cover the initial capital costs. However, once a university has purchased the supplies for this project, the recurring costs are minimal, consisting primarily of incentives for volunteers and awards for the winning students. A budget summary is given in Table 1.

In terms of the required supplies for this program, a miniature shake table is the most critical, as these devices are very expensive. At UCSD, we have an arrangement to borrow one that was purchased for research purposes. Next in importance is the volume of K'NEX for students to use. However, the costs quoted in Table 1 are assuming a program of 1,000 students – a smaller number would require proportionally smaller start-up costs. However, it is clear that in order to start such a program, we will need help from

Item	Quantity	Cost (ea)	Total:
Mini Shake Table	1	-	-
K'NEX kit	250	\$ 51.12	\$ 12,780.00
Other Testing Supplies	1	\$ 850.00	\$ 850.00
Volunteer Supplies	1	\$ 410.00	\$ 410.00
	Grand Total:		\$ 14,040.00

Table 1 - summary of required supplies and costs (assuming 1,000 students)

industry and university partners to obtain the necessary supplies.

Future

The tremendous success of the Seismic Outreach program at UCSD has motivated us to seek ways of expanding the program. Since its inception, each successive project has helped refine every aspect of the project to the point where it is now feasible to execute the program three times a year (each academic quarter) and host 500-1000 students for each program, with minimal costs and manageable volunteer effort.

Having maximized our capacity, we believe that now is the right time to partner with other universities to expand the reach of the project.

While we have made an effort to reach out to economically disadvantaged schools, UCSD's location in San Diego makes transportation to campus difficult for many of these schools. We feel that the most effective way to increase the program's reach to disadvantaged youth is to bring in universities that are located in close geographic proximity to those communities. In other words, expanding the network of universities hosting

similar programs is the best way to reach a more diverse population of students.

Through such expansion, it is our goal to encourage middle schoolers throughout Southern California and the Pacific Southwest region to consider STEM careers. If you are interested in participating in this effort, we need your help! To get more information on the program or how you can get involved, please contact us with the information below. Thank you for your interest in enriching STEM education!

"[The students] absolutely love this project. This type of hands-on learning is really effective and draws kids in and engages them in learning."

– Nancy Swanberg, Science Specialist, Del Mar Hills Academy

"The entire Seismic Outreach program was a terrific learning experience for our students."

– Larry Richards, Teacher, 6th grade Earth Science & Pre-Algebra, Twin Peaks Middle School

"The entire project was well organized and was a highlight of my students' year! My students learned a lot...much more than they would have simply by reading a book. The kids enjoyed [the field trip to UCSD] thanks to all of the project volunteers who interacted and played with them... We would love to do this again."

– Melanie Brown, Special Education Director, Poway Unified School District



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