DEVELOPING A SUSTAINABLE EARTHQUAKE ENGINEERING CURRICULUM FOR K-12 STUDENTS AND TEACHERS

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Overview

- Introduction
- Seismic Outreach Program at UC San Diego
- Project Impact
- Pilot to Standardize Curriculum
- Conclusions & Future Work
Introduction

- Recent push to improve K-12 STEM education due to losing interest in math and science [1].
  - Disconnectedness of K-12 science curriculum from content relevant to students’ daily lives [2].
  - Realization that engineering promotes problem-solving and must be integrated into K-12 classroom [3].

- Well-defined K-12 engineering curriculum aligned with standards are difficult to come by.
  - Current CA Standards and NGSS [5] provide engineering skills across all grade levels.
  - NGSS for 4th grade suggests designing earthquake resistant buildings to meet “4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural earth processes on humans.”
Seismic Outreach at UCSD

- Award winning outreach program for >15 years
- Run by undergraduates as part of SCSE
- ~2000 4th-6th grade students brought to UCSD annually
- Curriculum aligned with state and national standards in earth sciences, mathematics, and engineering design
- Two phases:
  - In-Class Presentations, about earthquakes, structural engineering and the K’Nex competition.
  - Field Trips: students given four weeks to create a structure to be judged (interview) and tested (instructional shake table) at UCSD. Given tour of campus and Powell Structural Engineering Labs, and interact with UCSD undergraduates

Current issues:
Seismic Outreach Field Trip
Project Scenario

A rich land owner is looking for the best design of a building in downtown San Diego near an active fault. Your goal is to make a model of an appealing, original, and economical building with lots of floor space out of K’NEX.

Students are placed in a Design-Build team of 4-6 to compete to win for the best design.
Rules

- Structure must be constructed only with the pieces provided in one K’Nex set.
- Teams may not exchange pieces among each other. All pieces and quantities must be recorded on Bill of Materials.
- K’Nex pieces may not be painted, glued, melted, bent, or modified.
- Base must be approximately 6” x 6” and have flat bottom.
Rules

- Every floor size of the building must not exceed 10”x10”. Students must calculate total floor area of structure.
  - A floor is any level plane parallel to the ground that can support a floor beam in two directions. Floors must be at least 2” apart.
- Structure must be at least 24” tall. No height limit.
- One story must be the length of a gray rod (~ 7 ¼ inches).
- On day of competition, mass will be applied to structure any location above 12”.
  - Orientation of structure on shake table is discretion of group.
Group Packet

- Registration form listing team members and name
- Scaled architectural drawing: creative rendering of structure depicting main building function,
- Scaled construction drawings: consist of one side view and one representative floor plan.
  - Represent actual structure built and drawn on eng. paper.
- Calculation details
  - Floor Plan Form (area of each, total # of floors, and total floor area,
  - Bill of Materials (total building cost & total floor area for PI)

\[ PI = 10^8 \times \frac{A}{C \times W} \times (1 - D) \]
In Class Presentations

- 2-5 UCSD students give 1 hr presentation at schools
- Topics include:
  - Plate tectonics, fault rupture, fault types, P-waves and S-waves
  - Famous past earthquakes and earthquake damage
  - Earthquake research: Shake table and large-scale structural testing
  - Forces: Tension, Compression, Torsion, and Shear
  - Structural Components & Behavior: Beams, Columns, Bracing, and Buckling
  - Roles of and relationships between Owner, Architect, Engineer, and Contractor
  - Introduction to K’Nex competition and rules
UCSD Field Trips

- Come to UCSD for a field trip. Transportation is provided by their school.
  - Potential hardship for underserved communities
- 2-4 rotations
  - Campus tour of UCSD and Powell Labs
  - Fun and games: interact with UCSD ugrads
  - Judging and interviews: Students present orally reasons behind design decisions, predictions of structure’s performance, answer questions from in class presentation
  - Shake table testing: using sinusoidal motion with increasing frequencies until natural frequency/resonance induced.
- Awards given at end of day
## Assessments

<table>
<thead>
<tr>
<th>Question</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCSD Seismic Outreach increased my understanding of how to design structures to withstand earthquakes</td>
<td>4.28</td>
</tr>
<tr>
<td>UCSD Seismic Outreach helped me better understand what I’m learning in my own classes at school</td>
<td>3.77</td>
</tr>
<tr>
<td>UCSD Seismic Outreach increased my interest in studying science and engineering.</td>
<td>3.84</td>
</tr>
<tr>
<td>UCSD Seismic Outreach increased my understanding of how engineers design, build and test innovations.</td>
<td>4.18</td>
</tr>
<tr>
<td>I am interested in going to college to study science or engineering.</td>
<td>3.53</td>
</tr>
<tr>
<td>Based on what I learned during this program, I am interested in learning more about earthquake engineering.</td>
<td>3.55</td>
</tr>
<tr>
<td>I would recommend the UCSD Seismic Outreach event to other students.</td>
<td>4.28</td>
</tr>
</tbody>
</table>
Assessments

- Instructional shake table helped the students understand importance of earthquake engineering most
  - “The part of the program that helped me understand the importance of earthquake engineering was when we actually put our structures on the shake table. This helped me understand the exact motion of the structure and realize without sophisticated engineering of structure we would be in serious trouble.”
Assessments

- Liked lab tour and shake table testing most
  - “I liked the tour of the college campus the best because many campuses have very cool buildings and structures and I like seeing what college campuses are like.”
  - “I liked the best when we tested our buildings, because it was very competitive, intense, exciting, and fun. I enjoyed learning about different types of bracing.”
- Liked interview the least because they were nervous feared saying something wrong would impact their group’s performance.
Standardizing Curriculum

- Evident that level of understanding and preparedness by students varied greatly depending on teacher interest and types of in-class activities conducted with students.

- Standardized curriculum through pilot study to integrate 4th grade EERI School Earthquake Safety Initiative curriculum (SESI) [8].
Standardizing Curriculum

- Two 90-minute lessons or broken to smaller chunks.
  - Introduces earthquakes, engineering process, and design elements which are then tested by the students to develop ideas for strengthening buildings.
  - Scaffolding provided through visuals of vocabulary and demonstrations.
  - Provides students with the challenge of designing their earthquake-resistant building and presenting their data to make a group decision for their design solution.
  - Six design teams define specific criteria and limitations for an earthquake-resistant building, test and refine their designs, collect data, and communicate their findings.
- Project culminates in the students testing their structures at UCSD on the instructional shake table.
Standardizing Curriculum

- During 2016-2017, one dedicated UCSD undergraduate student trained teachers, provided materials/kits for hands-on, in-class, testing, and instructions for how to build their own hand-operated shake tables for students to use during the in-class experiments.

- Survey of 8 teachers:
  - Liked new curriculum but require more training and not sure if it is too difficult for some students.
  - Materials provided on hands-on curriculum were not very easy to navigate.
  - Support provided by UCSD student was helpful.
  - New curriculum enhanced the overall design-based project experience.
Conclusions & Future Work

- Very successful program but at capacity.
- New curriculum is more effective in standardizing preparedness and overall student experience.
- Teachers require more hand holding and training to implement effectively.
- Teachers very interested in checking out shake table and being trained to do entire program on their own
  - Scalable approach to broaden participation
- Approach already tested in two large middle schools in the Poway Unified School District in San Diego
- 6 different science teachers serving over 450 students/
  - 1 teacher served 105 students.
NHERI@UC San Diego Outreach
Thank you! Questions?