Make Way for Trains: A Community-Connected Elementary Geotechnical Engineering Unit (Resource Exchange)

Dr. Chelsea J Andrews, Tufts University

Chelsea Andrews is a post-doctoral researcher at Tufts University and University of Massachusetts-Boston. She received a B.S. from Texas A&M University in ocean engineering, an S.M. from MIT in civil and environmental engineering, and a PhD from Tufts University in Engineering Education. Her current research includes investigating children's engagement in engineering design through in-depth case study analysis.

Nicole Alexandra Batrouny, Tufts University

Nicole Batrouny is a PhD candidate in Mechanical Engineering at Tufts University. Her engineering education research interests include upper elementary engineering education, integrated science and engineering, collaboration in engineering, and decision making in engineering. For her Master's thesis, she uncovered talk moves used by 4th grade students that fostered collaborative, disciplinary decision-making during an engineering design outreach program. For her dissertation, she intends to explore the ways in which team mental models function in teams of novice engineers and how novice engineers can be trained to collaborate more effectively on diverse teams.

Dr. Kristen B Wendell, Tufts University

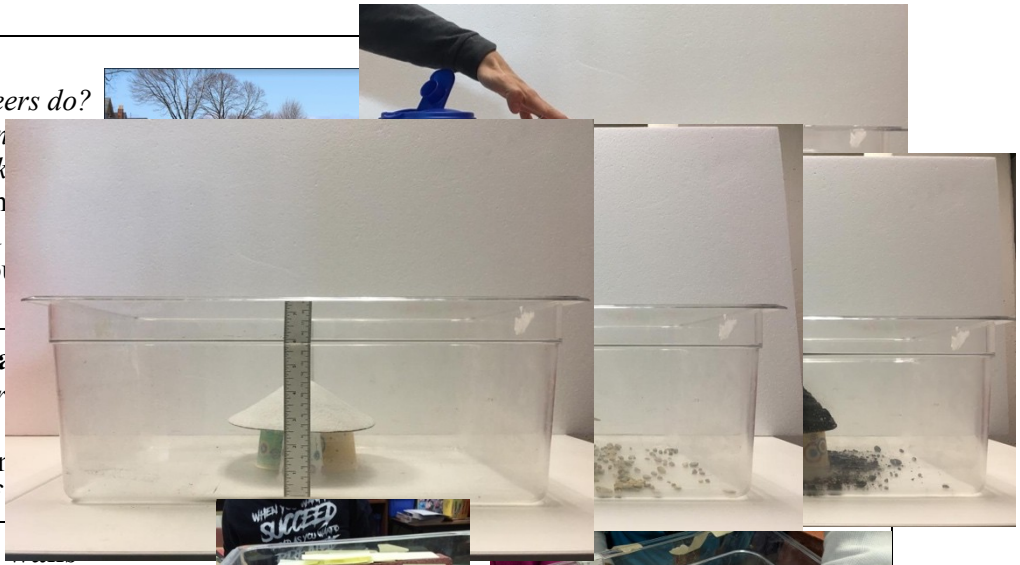
Kristen Wendell is Associate Professor of Mechanical Engineering and Adjunct Associate Professor of Education at Tufts University. Her research efforts at at the Center for Engineering Education and Outreach focus on supporting discourse and design practices during K-12, teacher education, and college-level engineering learning experiences, and increasing access to engineering in the elementary school experience, especially in under-resourced schools. In 2016 she was a recipient of the U.S. Presidential Early Career Award for Scientists and Engineers (PECASE). https://engineering.tufts.edu/me/people/faculty/kristen-bethke-wendell

Make Way for Trains: A Community-Connected Elementary Geotechnical Engineering Unit (Resource Exchange)

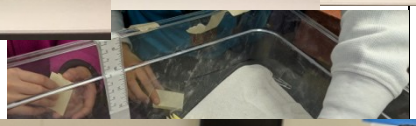
Grade level: 3-6 (meets 4th grade engineering and earth and space science standards)
Time: 8, 1-hour lessons. Final Design Challenge can also be a stand-alone design task
Standards: All NGSS 3-5-ETS standards are met, see full documentation for science standards

In the ConnecTions in the Making project, researchers and district partners work to develop and study community-connected, integrated science and engineering curriculum units that support diverse elementary students' science and engineering ideas, practices, and attitudes. In the units, students use human-centered design strategies to prototype and share functional solutions to a design challenge rooted in the students' local community while also exploring scientific explanations of the phenomena and mechanisms related to the challenge. In the "Make Way for Trains" unit, students explore key concepts of geotechnical engineering in the context of a train track expansion: as railway corridors are widened, the sloping earth material surrounding the tracks must simultaneously support existing structures and not fall onto the tracks.

Day 1. Unit Launch
What do geotechnical engineers do?
What are the problems they n
solve to build new train track
Students explore the problem
attempting to hold back sand
support a model house witho
building materials.



Day 2. Inquiry: Earth Ma
How do different earth mater
pile, and why?
Students pile different earth r
compare the slopes (angle of



Day 3. Design: Retaining
How can we design a wall to retain earth materials?
Students learn about retaining walls then design, build, and test their own designs in bins with sand.

Day 4. Inquiry: Soil stabilization
How do geotech engineers stabilize earth materials using textile materials?
Which textile materials work best?
Students layer sand with textile materials (mesh, jersey, coffee filters) and explore the strength of the resulting piles.

Contact: Dr. Chelsea Andrews (Chelsea.Andrews@tufts.edu)
Project Team: Dr. Kristen Wendell (PI), Dr. Tejaswini Dalvi (Co-PI), Nicole Batrouny
Link to full curriculum: https://bit.ly/connectionsengineering
The ConnecTions in the Making project is supported by the NSF, ITEST-1657218

Design Challenge: Earth Material Retaining System

In the final design challenge, students design, build, test, and iterate on a scale model solution to the earth material retaining problem in a large clear plastic bin. When done as part of the unit, the design challenge typically spans 4 days, but it also works as a 1-day stand-alone design task.

Day 5: Planning	*What are important things to consider when solving a design challenge?* Groups sketch and discuss initial ideas, begin fabricating pieces if time.
Day 6: Building & testing	*How do we know if our design works? How can we use failures to improve our designs?* Groups build and test their designs. Nearly all the initial designs fail the test; groups iterate and continue testing, trying to improve their designs.
Day 7: Reflection	*What can we learn by looking across all our design attempts?* Groups reflect on their design attempts; teacher facilitates a whole class discussion comparing across designs.
Day 8: Design conference	*How do engineers share their ideas through speaking and writing?* Groups share their designs and design process with other students and members of the school and greater community.

DESIGN BRIEF

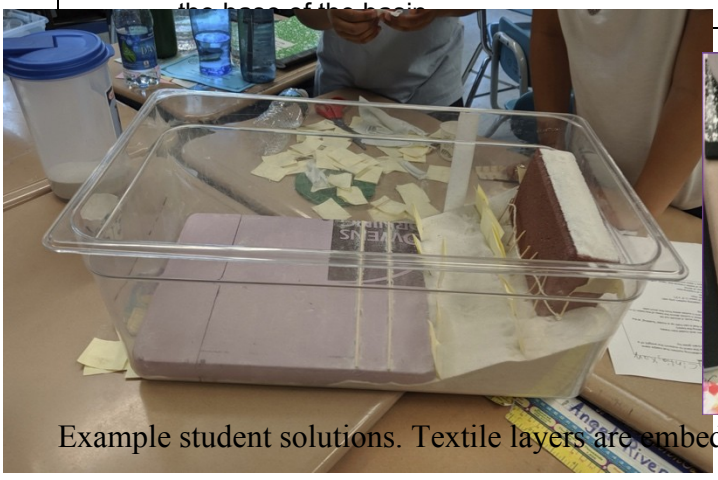
Goal: Design, build, test, and iterate on a retaining structure that keeps sand away from the model train tracks, allows the sand to support the weight of a model building, and stays up when the train goes by.

Criteria: Your structure MUST:

- Keep all sand off of the pink foam and model train tracks.
- Withstand "train rumbling" (shaking the basin).
- Keep the sand stable enough that it can hold up a model "building" (brick).
  - The building MUST be kept level, so it does not tilt.
  - The building is located 4 inches above the base of the basin.

Constraints:

- You may build your retaining structure only with:
  - Small slips of paper (1.5" x 2")
  - Paper clips
  - Toothpicks
  - 6 inches of masking tape
  - 4" squares of textile materials (cotton, mesh, coffee filters)
- You only have 1 class period to build your structure.



Example student solutions. Textile layers are embedded in the sand and no longer visible.

Contact: Dr. Chelsea Andrews (Chelsea.Andrews@tufts.edu)
Project Team: Dr. Kristen Wendell (PI), Dr. Tejaswini Dalvi (Co-PI), Nicole Batrouny
Link to full curriculum: https://bit.ly/connectionsengineering
The ConnecTions in the Making project is supported by the NSF, ITEST-1657218