



Design and implementation of a hands-on water engineering challenge for a public science center: an interdisciplinary collaboration of scientists, engineers, and museum educators



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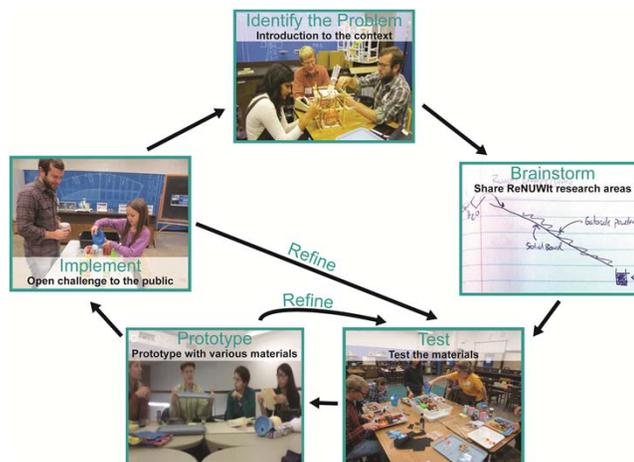
Re-Inventing the Nation's Urban Water Infrastructure (ReNUWIt)

1. Lawrence Hall of Science, 2. ReNUWIt, 3. UC Berkeley, 4. Stanford University

SUMMARY

Hands-on design activities can be an effective way to engage K-12 students in science and engineering. Our interdisciplinary team created a hands-on, engineering design challenge about managing stormwater in cities. The exhibit was showcased for nine days (36 hours) in February 2013, and >1000 visitors participated in the challenge (average of 125/day). Participants designed and built a portion of a city landscape using simple materials and tested their city's ability to retain stormwater, prevent flooding, and capture pollutants, while considering ecological impacts. Visitors iteratively improved their designs, often designing multiple city landscapes with the reusable materials. The challenge appealed to both female and male children, visitors stayed an average of 32 minutes (+/-14 minutes), and survey responses demonstrated visitors' understanding of the issues and terminology of infiltration and runoff, as well as the importance of green infrastructure in urban design. The collaboration provided valuable experience for the design team as well as the students who volunteered to serve as experts.

The design process of the designers in the creation of the exhibit



BACKGROUND

The Ingenuity Lab at the Lawrence Hall of Science is a novel learning space for families of all ages to tinker and engineer solutions to design challenges. The Ingenuity Lab is currently open to the public on a drop-in basis during weekends, providing open-ended, tinkering design challenges to about 800 visitors each month, with ages ranging from toddlers to elderly. Each month, an engineering design challenge and theme is presented to visitors, along with appropriate materials. The engagement of the Hall with ReNUWIt offered a unique, mutually beneficial opportunity for the Hall and ReNUWIt to address their respective goals.

METHODS

- Pre-post survey summary of the project designers
- Participation of diverse student facilitators and staff and their feedback
- Participation of Ingenuity Lab visitors and their feedback
- Participation by diverse audiences

GOALS

Lawrence Hall of Science	ReNUWIt
<ul style="list-style-type: none"> • To inspire and foster learning of science and mathematics for all, especially those who have limited access to science. • Expose visitors to engineering design through hands-on activities. • Promote inter-generational collaboration. • Appeal to and engage people of diverse backgrounds and ages. • Offer complex and realistic content. • Provide an open-ended and personalizable experience. 	<ul style="list-style-type: none"> • Develop a hands-on module about urban water infrastructure that can be "on-the-go" and used/modified across the ReNUWIt campuses for various education/outreach opportunities. • Expose students/post-docs/staff to Ingenuity Lab's design challenge design process. • Strategically reach a large number of outreach participants in an informal setting. • Provide volunteer opportunities for ReNUWIt students and post-docs. • Increase public exposure/recognition of ReNUWIt.

Photographs of the design challenge implementation



RESULTS

The ReNUWIt team members offered a wide range of definitions for what engineering meant to them. In the initial survey, team members expressed interests in how urban water infrastructure can be used to benefit ecology, how natural systems can work within engineered systems, and how humans affect the water cycle. Post collaboration, the team reported improved communication skills and an enhanced ability to explain their research to a diverse audience.

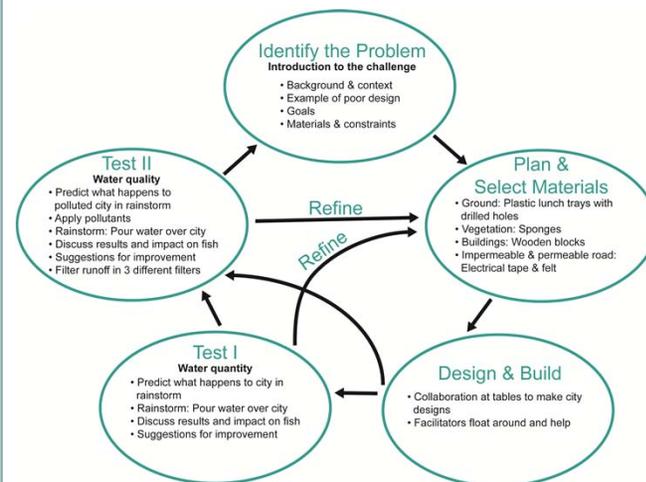
Undergraduate volunteers included 10 students in Berkeley Engineers and Mentors (6 females, 4 males), whereas graduate student volunteers included 15 students (11 females, 4 males). These volunteers received training in teaching techniques from the staff. Feedback collected was categorized into facilitation, training, visitor introduction, building, testing, and resources and extension.

The visitors included 911 people who were tracked, but this total includes at least two days in which not all visitors were counted. The visitor responses to the survey were overwhelmingly positive, and varied in terms of what the visitors thought was their favorite part and surprising aspect.

The materials and challenge have been adapted for use by ReNUWIt in a water festival in Irvine, CA, for a local middle school class in Berkeley, CA, and for a teacher training workshop in Golden, CO, planned for summer 2014.



The design process for visitors participating in the exhibit



Example quotes from the participant survey

Date	Children's Age/Gender	Favorite Part	Surprising Aspect
2/2/2013	6M, 9F	"The trying to save fish by having non-polluted water"	"Kids did better than Grandma"
2/9/2013	14M, 9F	"Hands on design experience"	"Learned that fertilizer also not so good for nature"
2/9/2013	6M	"Pollution station"	"6 year old able to understand"
2/9/2013	8, 3, 7 months	"The techs"	"How the kids are always interested"
2/17/2013	5M, 4M	"Building and testing city design for water flow"	"Easy to see differences in city design"
2/24/2013	2.75F, 5 F	"The city/drainage models"	"Clear to children and relevant"

DISCUSSION

Impact on the public

- This design challenge fosters ownership, offers free-choice learning, and is accessible to diverse learners.
- The design challenge engages learners in real-world design challenges.
- This challenge can easily be adapted for various settings for broader impact and marks a promising step towards meeting the Next Generation Science Standards in the United States.

Impact on the design team

- We developed a design challenge through interdisciplinary collaboration that communicates the mission and research of ReNUWIt to the community.
- The collaborative design process benefitted the designers, student facilitators, and community.