Outreach Playbook

SWE Boston Environmental Challenge

Metrics:

Grade Level: 5-8	# of Student Participants: 14	Duration (hrs): 2.5 hours	# of SWE Volunteers: 3	Partner orgs (if any): McCall Middle School (Winchester MA)

Overview of Activity

1) The SWE Boston Environmental Engineering Challenge is a single-day event where students use project-based and self-regulated learning along with STEM concepts to design an innovative solution within their team. For the first challenge in 2022, teams will design a storm drain for city water runoff. Teams will design their drain from household craft material like screens, cotton balls, duct tape, foil and popsicle sticks. Pollutants will be simulated by small items like paper, Styrofoam balls and toothpicks.
2) Students will learn:
    a. The Engineering Design Process, since they will be brainstorming, sketching, planning materials, prototyping, testing, and then redesigning their storm drain systems.
    b. Teamwork, since they will be working in teams to collaborate on ideas, distribute prototype build and test tasks, and decide as a team on the final design elements.
    c. How stormwater drains work and how their design can hugely affect their communities.
3) Real-life connection: An example was provided at the beginning of the activity that when a particular stormwater drain was not filtering out pollutants, a local beach was becoming polluted and had to be closed to visitors. If the drain's design could be fixed, the beach could be opened again and enjoyed by the community.

Outline and Script

1) 1:00-1:20PM – Intro, review challenge parameters
   a) Introduction presentation
      i) Present the background behind storm drains - where does the filtered water go? Differences between stormwater and wastewater, etc.
      ii) Present an example problem: a beach is not usable at certain times of year due to water pollution. Let's fix that with a good storm drain!
      iii) Ideally this presentation will be done by a real female stormwater engineer! Check your local water authority to see if they can send someone to present.
   b) Challenge introduction
      i) Present the challenge details:
         (1) How to mix the stormwater (2-3 T solids per 1 cup water)
         (2) Teams will use the same household materials to design, prototype and test a storm drain that captures pollutants and filters them out of the stormwater.
         (3) Teams will use the engineering design process to brainstorm, sketch, select their materials, build a prototype, test it, then redesign and test again.
         (4) Each team member will sketch their design, then the team will select the best design, or combine elements of several designs as their final design
      ii) Challenge limitations/parameters (distribute rubric at this time):
         (1) Design must stay within budget
            (a) Lower cost = more points to that team
         (2) Design must remove as many pollutants from entering the drain system as possible
            (a) More removed = more points
         (3) Design must allow 1 cup of stormwater to flow through in 1 minute or less
            (a) Faster flow = more points
         (4) Lifecycle: filter must still function after 5 flow cycles.
            (a) More cycles = more points
         (5) Limit flooding and leaks as much as possible
      iii) Materials:
         (1) Drain system materials: plastic cups, plastic tube, small box or prop (to prop up the drain tube), plastic tub (to catch leaks), and Styrofoam plate or other container to catch filtered stormwater at end of drain tube
            (a) These materials are all 'free' and do not count towards the team's budget
            (b) Each team gets one of each to start, and if they destroy that item during design or test, it may be replaced by a volunteer.
         (2) Pollutant materials: Styrofoam, paper, pieces of toothpick
            (a) Other possibilities: sand, oil, food coloring, soap
         (3) Drain design materials: screen, toothpicks, popsicle sticks, cotton balls, duct tape, foil (these all need to be count towards the team budget)
         (4) Plastic teaspoon for scooping pollutants into water
            (a) 2-3 T solids per 1 cup water
2) 1:20-2:05PM – Design part 1 (go to breakout rooms if virtual)
   a) Tips (volunteers share as needed with teams):
      i) Leak check is recommended with plain water prior to first test

ii) Structure of the drain prop is important – once the cup is filled with water it can easily tip over
iii) Angle of top grating (if used) is important too – if the cup is at an angle, water could run off the grate surface instead of into the cup
iv) A crisscross style grate works better than just one set of parallel bars
v) Use tape to seal the gap between filter and cup/tube

3) 2:05-2:20PM – Design peer review (combine 2 breakout rooms if virtual)
   a) Teams are paired up to share their initial design and get feedback and ideas from the other team
4) 2:20-2:30PM – break
5) 2:30-3:15PM – Design part 2
   a) Testing + iterating
   b) Have teams also think about how to divert stormwater away from drains in the first place - green spaces/soil, permeable pavement, green roofs, etc.
6) 3:15-3:30PM – Rubric review
   a) Teams review rubric and give themselves a score for each item
7) 3:30-4:00PM – Team design presentations (breakout rooms close if virtual)
   a) Something they learned about stormwater
   b) Lessons learned: What would you tell the next team that picks up your design where you left off? What other ways can we divert stormwater?
8) 4:20-4:50PM – Judging period (Facilitators meet in a breakout room if virtual)
   a) Real-world presentation for students in main Zoom room
      i) Stormwater engineer will present an example of storm drains in real life
      ii) Leave time at the end for Q&A
      iii) At the same time, facilitators score each team's design based on the rubric
         (1) At a smaller scale, the rubric review can be the team's final score and the prizes can just be based on the score
9) 4:50-5:00PM – Prizes awarded and wrap-up
   a) Best overall score, Lowest budget, Fastest flow, Longest lifetime, Best collaboration
   b) Most creative and/or most inconspicuous/realistic? (if more are needed)
   c) Each team member will also receive a certificate of completion

Example of storm drain design:

Lessons Learned

1) Pricing updates: All teams stayed well under $125 so the original list might work better in the future.
    a) Original prices developed during volunteer pilot build:
        i) Screen = $40
        ii) Cotton ball = $10
        iii) Duct tape = $20/ft
        iv) Foil = $10/sq ft
        v) Toothpick = $1
        vi) Popsicle stick = $2
    b) Actual prices used during event:
        i) Screen = $25
        ii) Cotton ball = $5
        iii) Duct tape = $36/ft
        iv) Foil = $6/sq ft
        v) Toothpick = $1
        vi) Popsicle stick = $2
2) Updates to times:
    a) Intro: 20 min was good for the intro, they were ansty to begin, but maybe 10 more minutes of real-world context would have helped them connect it to their own communities
        i) If we can get a speaker at the next event, definitely add another 10 minutes at least, maybe 15 more
    b) Design round 1: Give at least 45 min for the first design iteration. Most teams didn't get to test with stormwater during this round, only water, and we used 45 minutes on 3/20.
    c) Peer review timing depends on how many teams review at once. We had 3 teams share their designs and it only took 10 minutes, so 10-15 is a good estimate for this part.
    d) Break: We skipped this. With middle schoolers, this might disrupt their focus. If we stick to a total 3 hour event, I don't think we'll need a break.
    e) Design round 2: 1 team used 75 minutes for this, but the other 2 used between 45 and 60 minutes.
    f) Rubric review: This only took about 5 minutes, so 5-10 minutes is good for this for scheduling.
    g) Design presentations: This only took us about 10 minutes too, but we only had 3 teams. Writing down what they should talk about during their presentation would be helpful (like on the chalkboard or display it on a large screen).
        i) After presentations, we spent about 10 minutes talking about how this fits into our communities and how we could divert stormwater without using underground piping like storm drains. Ideally, a real stormwater engineer would present a real-world example for 15 min or so to wrap it up here.
3) Provide 1 price list per team - either printed on back of rubric or handwritten and distributed
4) Wait to hand out materials until all the rules are read and understood by the teams. They will get anxious to start designing right away and play around with the materials so it's easier to just wait.

5) More clarity on the rules before design begins:
    a) What can be used for free: 1 cup, 1 box, 1 tube
        i) Can the box be part of the filter design, or only used to prop up the tube? We didn't specify this so one team used the box as part of their filter design, but in the end moved away from the design anyway. Another team cut a circle out of the box to use as part of the filter, which I would say is totally fine, but this needs to be clarified at the beginning. If we are moving away from the paper box (see item 12) it will be harder to modify and use that as part of the design, but anyway it should still be clarified.
        ii) Teams can replace the cup and box as many times as needed throughout the design, but can only use 1 of each in the final design.
    b) What can be used in the design: 1 cup, 1 box, 1 tube, any items in the price list
    c) What cannot be used in the filter design: 2nd cup (this is for mixing and pouring stormwater), plastic spoon (for scooping stormwater solids and mixing), paper towels or napkins (these are for cleaning up spills), stormwater solids (spaghetti, paper bits, styrofoam balls), paper (this is for sketching your design).
6) Find a better way to catch water. Perhaps have water come out of the drain and off the side of the table into a tall bucket?
    a) We used small plastic plates on 3/20, which didn't hold more than 1-2 cycles of filtered water. Then we found some cafeteria trays which worked a lot better. There should be something fairly flat to catch water at the end (or far from the table like a bucket on the ground), and also something to catch leads towards the top of the drain (where the cup meets the tube, this is where most leaks happen).
7) Room where the kids are designing their drains will ideally has lab type tables with at least one sink in the room.
    a) Alternative would be bringing gallon bottles of water, but this is more wasteful.
8) Provide one 12" ruler per group
9) Provide one stopwatch per team. Could be a phone but MyChron stop watches from Stokes Publishing Company worked really well.
10) Bring extra cups - some teams went through 5 or more
11) Have tape and foil priced per inch for the budget
    a) Teams will sometimes only need 2 extra inches of tape at a time while they are designing.
12) Have paper towels available - LOTS of them
13) Have method to remove foam balls from water, so they don't get dumped down the drain. Could use the mesh or a mesh scoop.
14) Replace paper box with acrylic or plastic cube that is 3 or 4 inches square. See link: https://www.amazon.com/dp/B092Q6SXRN/ref=cm_sw_r_apan_glt_i_EBEGD7KYX6CXYWF1978J

Accessibility Adaptations

- **Smaller budget**: PVC tubes could be cut instead of ordering the pre-cut clear tubes. It is nice to see the water flowing inside the tube, but other, cheaper tubes can easily be replaced for this challenge. All other materials are very inexpensive and/or can be easily swapped for another household item.
- **Internet**: No internet is needed for this project.
- **Virtual**: This challenge can be easily completed in a virtual or hybrid environment. The teams can be in-person with the volunteers virtual, as long as the teams are far enough apart to be on the same Zoom call without echoing. The beginning and end will be one Zoom room, and then the design iterations will be breakout rooms with the teams and at least 1 volunteer in each breakout room to help them if they get stuck. If teams are completely virtual, each team member would design a prototype, and then the team will design which one to move forward with. Completely virtual teams would become a bit more expensive, since each team member needs all the materials instead of one set of materials for each team. More time should be allotted for a virtual challenge as well.

Materials and Costs

Item	**Quantity**	**Where to Buy (link if applicable)**	**Total Cost**
Plastic tube	1 per team (if completely virtual, 1 per participant)	https://smile.amazon.com/gp/product/B093GS1T7R	$21.99
Plastic pint cups	7 per team		Already in SWE Boston inventory
Styrofoam balls	1 container per 10 teams	https://smile.amazon.com/dp/B07454ZR6H	$9.99
Mesh screens	2 per team	https://smile.amazon.com/dp/B08DFQ4TR7	$6.99
Duct tape	1 roll per 10 teams		Already in SWE Boston inventory
Cotton balls	5 per team		Already in SWE Boston inventory
Stopwatch	1 per team	https://www.schoolspecialty.com/stokes-publishing-mychron-timer-red-pack-of-6-	$47.32 (these were already in the classroom so we did not purchase)

		193-6112	
Prop box	1 per team	https://www.amazon.com/dp/B092Q6SXRN	$20.99
Toothpicks	25 per team		Already in SWE Boston inventory
Popsicle sticks	10 per team		Already in SWE Boston inventory
Paper	10 sheets per team		Already in SWE Boston inventory
Foil	1 roll per 10 teams		Already in SWE Boston inventory
		Total cost	***$59.96***
Describe any additional funding sources outside of section budget (if applicable): N/A			