From Here to There

Students design a multi-use trail to get pedestrians, bicyclists, and rail cars where they need to go.

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**Time Required**

- **Advance Preparation**: 20 minutes
- **Set Up**: 5 minutes
- **Activity**: 40 minutes
- **Clean Up**: 15 minutes

**Supplies**

For each group of students:

- Tennis Ball or other large heavy ball
- 2 marbles or 2 other small heavy balls
- 2 ping pong or 2 other small light balls
  - Prototyping supplies such as:
    - Paper towel tubes
    - Masking tape
    - Yogurt cups (optional: cut out bottom)
- Aluminum foil
  - Sturdy boxes

Per each individual student:

- Copy From Here to There project sheet
- Copy Sketch Pad sheet from Appendix C
INTRODUCING THE ACTIVITY

The goal of this activity is to get students to identify the criteria and constraints involved in an engineering challenge. Invite the class to a “Design Meeting” and tell them they are civil engineers being asked to design a pathway for people to get from point A to point B. The path should be ‘multi-use’, meaning it will be used by people, bicyclists, and a light rail commuter train. Ask where issues like this occur in the world, and why a task like this is important.

Tell the students they will be developing a prototype, or model of a multi-use path. For their prototype of the path, different types of balls will represent the users: a tennis ball for the train, a marble for the bicyclists, and a ping pong ball for the pedestrians. Ask the students to list some things the path would need in order to be successful for each user. This list may include:

- A separate path for each user to keep them from bumping into each other
- It should work over and over for all three balls
- The balls should move without help
- The design shouldn’t use too many resources

Help the students refine this list until you’ve agreed upon the criteria for the challenge. If the students miss an important criteria, tell them the city planners have their own set of criteria the engineers must take into account. Having each ball succeed 3 times is a good example of this. This is a good opportunity to tailor the level of challenge to your students. More strict criteria will make the activity more challenging.
Show students how to set up point A and B. Explain that these points cannot be moved or changed. This can be any two points in your classroom, or on student desks. A basic setup would have point A a couple feet from B and a foot higher. This is an opportunity to tailor the level of challenge by increasing or decreasing the distance between points or the difference between their heights.

Break the class up into the engineering groups you have chosen, and make it clear that they will need to use all of their team members’ skills and creativity to come up with a solution. One at a time, give each group their challenge worksheet and send them to their designated design area.

**CLASSROOM ACTIVITY**

**Students should work in groups of 3-5. Each group follows the directions below.**

1) Introduce the activity.
2) Make sure a list of agreed upon criteria is on the board or other easily viewed location.
3) Show the students what Point A and Pont B look like, explaining that these points cannot move.
4) Before handing out the test balls, prototyping materials and worksheet, explain to students that once they get these materials, they need to spend at least 1-2 minutes quietly looking at the supplies and thinking of designs.
5) Pass out the materials to the groups.
6) Give students 5 minutes to discuss and sketch design ideas with their group; still no building at this point.
7) Allow them to build for about 10 minutes before the first round of testing. Students need to discuss whether their pathway was successful or not, given the criteria and modify as needed. If the pathway was successful, how many times does it need to prove so in order to meet criteria?
8) Instruct groups to test their prototypes. Then discuss whether their pathway was successful or not, given the criteria. If the pathway was successful, ask groups to consider how many times it should be tested to prove the design met criteria.
9) Ask groups to propose modifications.

10) Give an additional 5-10 minute build period for modifications and further testing. Repeat as necessary to meet criteria, and/or allotted activity time.

11) Give the students a 5 minute warning before asking them to stop working.

12) Allow enough time at the end for each group to describe their design to the class and run one or more tests (usually about 5 minutes per group). To complete the presentations in one class period, you may need to sub-divide the class for presentations.

Instruct groups to clean up by disassembling the designs and sorting the materials for future reuse.

14) Follow up the activity with a discussion of the engineering processes the groups used.
What are the different needs in a path for different types of transportation (train, car, bike, pedestrian)?
Facilitate a discussion about how engineers must account for various needs when designing solutions to problems. Note any times when different needs conflict with each other. Ask about possible solutions.

What was the most challenging part of solving this problem?
Students may say that the limits on their materials or the amount of time they had to build were a challenge.

Engineers often have to work within very challenging constraints on budget and time. Ask how they would work differently next time to give themselves more time or use their materials more efficiently. Students may say it was difficult to get the balls to repeat the process three times in a row.

Most problems need a permanent solution which can be repeated over and over. This is a concept called reliability. Ask the students why solutions should be reliable and how engineers can increase the reliability of their designs.

Criteria and constraints both need to be considered in engineering design. Criteria are the wants; constraints are the needs. For example, criteria for aqueducts may include moving water from one place to another efficiently, in addition to looking attractive in order to blend in with a community aesthetic. Criteria are the standards by which the design is judged. Constraints add limits. There may be certain laws in place concerning where the aqueducts can be placed, how they look, what materials can be used, etc. There are also cost constraints to consider.

By creating a prototype of a design, the item or solution can be tested and altered as needed before investing in the actual construction. Prototyping creates the information needed for construction, such as materials, quantity, size, etc.—all the specifics.
A. Budget
See the Budget extension in Appendix A. This introduces an additional constraint and will encourage the students to spend more time on design before constructing their prototype.

B. Roles
See the Roles extension in Appendix B. Along with some of the more typical roles of project manager, designer, and production try assigning roles based on the three user groups of the path. These students would be responsible for advocating for the needs of their particular group.

CROSS-CURRICULAR CONNECTIONS

CIVICS
Conduct a mock debate and vote
Assign students two advocacy groups and give them time to research and prepare arguments for or against the path receiving extra funds to include cars.

MATH
Students can measure the distance traveled by each of their balls and the speed and/or velocity at which each traveled (speed=distance/time; velocity=distance/time). They can then graph the results.

LANGUAGE ARTS
Have students create a brochure, presentation or video that clearly advocates for their design and why it should be chosen from the many project “bids” by various design firms.
What's the Problem?

What are the criteria for success?

What are the constraints?

- Each ball may only be pushed once.
- Each ball must make it from A to B, three times in a row.
- If any ball falls to the ground, you need to start over again from the beginning.
- The start/finish blocks need to remain in their marked positions. They can’t be moved or knocked over.
- What are the limits on materials?

Develop a Solution

- What will your design look like? Draw your design on the sketch pad worksheet.
- What materials will you use?

Test and Refine

- What parts of your design worked? What parts didn’t?
- What did you change in your prototype?
- How well did your design work?