Types of Engineering

STOMP
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Notes

Description
This is an 8-10 week curriculum that is designed to introduce 4th-5th grade students to a wide range of engineering fields. During each lesson, the students are exposed to a different type of engineering through a hands-on activity. The lessons may be adapted to fit your teaching style, timeframe, available materials, and students.

Application
Be careful to maintain a consistent lesson structure so that students are better able to draw connections from week to week. Otherwise, the unit can become disjointed and confusing. For that reason it is helpful to tie back all of the projects to the engineering design process.

Furthermore, preparation of teaching material is key. Before teaching a lesson, familiarize yourself with the important vocabulary and material that is relevant to that particular field of engineering. Decide what is important for the students to know and what you want them to take away from the lesson. Finally, if you are unsure of how to use any of the technology or materials mentioned below, learn about them and play with them before going into the classroom.

During each lesson, it is important to give the students opportunities to fail, struggle and then solve their own problems. While you don’t want your students to become too frustrated, try to avoid giving them your own solutions or design ideas. Instead when a student comes to you with a problem, try to ask a series of guiding questions to help them arrive at their own solution. One technique is to rephrase the students’ words such as, “I think you’re trying to... is that correct?” Sometimes by looking at the problem from another angle, the students come up with a solution.

Questions for STOMPers
You may want to consider the following questions over the course of the semester:
What do you want to see your students doing in this unit? How are you going to present the engineering design process? What do you hope your students will learn? How will you measure your students’ progression? How can you make the activities relevant to the real world? What interpersonal skills do you want them to practice?

Questions for Students
What do engineers do? Are you an engineer? How do engineers behave and work together? How do engineers approach problems? How do engineers feel about failure? What types of real world work to engineers do? What are the different types of engineering? What do they have in common? What’s different about each type?
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Lesson 1: Paper Towers

Overview: This lesson introduces the engineering design process (EDP) by engaging the students in the paper towers challenge.

Learning Goals:
1. Students will practice applying all steps of the EDP.
2. Students will develop interpersonal skills and presentation skills.

Materials/Preparation:
• Building Materials: 18” of tape, 5 paper clips, 5 index cards, and 8 sheets of 8.5 x 11 paper (please use scrap paper from the recycling bin)
• A stack of books for testing

Lesson Plan:

1. Introduction (20 minutes)
   o Introduce yourselves and introduce the idea of “engineering.” Ask: “What do engineers do?” Mention that there are many different types but that they all help people solve problems to make the world a better place!
   o Establish a set of classroom norms (see References).
   o Present the EDP in an engaging way. Before class, decide which version you are going to teach (there are many versions! You can even come up with your own). Use the same model throughout the 8-10 lessons.

2. Main Activity (30 minutes)
   o Using the materials, students will create a structure to support a stack of books.
   o Ask the class what types of shapes or approaches may work best to solve the problem. Have each group make a sketch of their plan.
   o Give the students time to work. Throughout the work time, encourage students to test and redesign. Sometimes students are shy about testing. You may want to require the students to do one test after 20 minutes.

3. Wrap-up (10 minutes)
   o Have each group explain their design and do a final test for the class.
   o Discuss: What designs worked best? What shapes did you use to make the towers strong? What materials were most useful? How would you improve your design?
   o Relate the activity to the EDP (e.g. What did you do to test your tower?)

Modifications: Other good intro activities include: Aluminum Boats, Spaghetti Towers, Egg Helmet, and Build a Chair for Mr. Bear (See the STOMP activity database for more details).
Lesson 2: Popsicle Stick Bridges

Overview: Students learn about civil engineering by building bridges with Popsicle sticks and tape.

Learning Goals:
1. Students will recognize where the work of civil engineers is present in their lives.
2. Students will practice applying all steps of the engineering design process.
3. Students will practice their interpersonal skills and presentation skills.

Materials/Preparation:
• 30 popsicle sticks
• Tape and a ruler (2 feet of tape per group)
• A stack of books for testing

Lesson Plan:
1. Introduction (10 minutes)
   o Explain what civil engineers do and give the students some information about bridges. To make the lesson more exciting, you may want to bring in pictures, videos or models.
   o Review the EDP. Write it on the board so that you can refer back to it.
2. Main Activity (40 minutes)
   o Explain to the students that their bridge will have to span the one-foot gap between the desks. Their goal is to hold up as many books as possible while connecting the two desks.
   o Have the students quickly draw a sketch and urge them to agree on a design before building.
   o Next, distribute the materials and let the students build their prototypes, test, and redesign at their own pace.
3. Wrap-up (10 minutes)
   o Come together as a class and have each pair describe their bridge then test it by gently putting books on top of it.
Lesson 3: “I Love that Dirty Water”

Overview: This activity introduces the students to environmental engineering by challenging them to clean dirty water.

Learning Goals:
1. Students will be able to describe what environmental engineers do.
2. Students will practice applying all steps of the engineering design process.
3. Students will develop their interpersonal and presentation skills.

Materials/Preparation:
• Filter fillers: sand, gravel, cheese cloth, coffee filters, cotton balls,
• 1 or 2 mixtures of dirty water (with sand, small rocks, oil, glitter, food coloring, etc.)
• Building materials: rubber bands, string, tape, popsicle sticks, paper, plastic bottles
• speakers to play “Dirty Water” by the Standells (optional)

Lesson Plan:
1. **Introduction** (5 minutes)
   o Explain that environmental engineers design systems that clean water, air, and land so that humans and animals can live safely on earth. You may want to review ways in which environmental engineers clean water.

2. **Main Activity** (45 minutes)
   o Give each pair of students a cup of dirty water (can be the same as or different from other groups). Tell them they must design a water purification system to clean their water sample. Use the word “system” rather than “filter” so that the prompt is more open ended. (e.g. perhaps the students want to let the mixture sit so they can skim the oil off of the top.) Have the students brainstorm for a couple of minutes.
   o Once the students’ finish their plans, they may request materials to take back to their seats. Give students time to build.

3. **Wrap-up** (10 minutes)
   o Come together as a class and have each pair describe its filter. Have each group demonstrate. Discuss the results.

Modifications: You can use an NXT light sensor to measure the amount of light that passes through the water to measure how well the filter worked.
Lesson 4: Squishy Circuits

Overview: Students will use play-doh squishy circuits to learn about electrical engineering.

Learning Goals:
1. Students will be able to describe what electrical engineers do.
2. Students will practice applying all steps of the engineering design process.
3. Students will understand the basics of electricity and circuits.
4. Students will develop interpersonal and presentation skills.

Materials/Preparation:
- Play-doh
- 9V batteries, alligator clips, light bulbs, motors (bring extras in case any parts are broken)
- newspaper for desks

Lesson Plan:
1. **Introduction** (25 minutes)
   - Discuss what electrical engineers do.
   - Then give the students the background knowledge they will need to build circuits. Explain the basics of electricity by doing an abbreviated version of *Act Out Electricity* (see the Activity Database for more details) or drawing on the board. Teach the students only the necessary parts of the circuit (battery, load, and wire.)

2. **Main Activity** (25 minutes)
   - Give each group of 2-3 students some circuit materials. Let the kids make electronic art using lights, motors and different colored clay.

3. **Wrap-Up** (10 minutes)
   - Have each group present their circuit. Have them explain how the electrons flow through the circuit. This will help them to solidify their understanding of electricity.
Lesson 5: Human Robot/Introduction to Scratch

Overview: This lesson uses the Scratch program to teach students about the basics of computer science and programming.

Learning Goals:
1. Students will be able to describe what computer scientists do.
2. Students will practice programming in pairs and collaborating on projects.

Materials/Preparation:
- computers with Scratch (1 per pair + 1 for the STOMPers)
- projector for programming as a class
- human robot props (optional)

Lesson Plan:
1. Introduction (25 minutes)
   - Introduce the students to computer science by brainstorming things that have been coded/built by computer scientists. Explain that computer scientists use computer languages to give robots instructions.
   - Do the Human Robot activity (see References).
2. Main Activity (30 minutes)
   - Next, pair up the students and give each pair a computer. Connect your computer to the projector and show the students how to open Scratch (see References for information about Scratch). Relate Scratch to the Human Robot activity by saying that your sprite is the robot and the blocks are the commands.
   - Demonstrate a simple program with movement commands. Have the students copy it and test it.
   - Introduce the challenge for this class and the next: to make a music video. Talk about the limits of what the students will be able to do. They should be able to choose a background, make the sprite “dance” (slide, change colors, rotate) and make noises.
3. Wrap-Up (5 minutes)
   - Ask the students to share out anything interesting or cool that they discovered when they were playing with Scratch.

Modifications: Have the students make an animated greeting card. For an extended computer science unit with Scratch, you can have larger groups of students collaborate on a video game.
Lesson 6: Scratch (Part II)

Overview: This lesson builds off of the last lesson by giving the students a chance to do a creative project on Scratch.

Learning Goals:
1. Students will be able to describe what computer scientists do.
2. Students will practice applying all steps of the engineering design process.
3. Students will develop collaboration skills by working in pairs.

Materials/Preparation:
• computers with internet (1 per pair, 1 for STOMPer)
• projector for programming as a class

Main Activity:
1. Introduction (<5 minutes)
   o Review what computer scientists do.
   o Review the challenge from the previous week.
2. Main Activity (45 minutes)
   o Let the students work on the music video.
   o About half way through the work time, write a simple dance yourself. Then demonstrate to the students how you can make the robot repeat the dance moves with a loop. Circulate the room and help kids that need further explanation.
3. Wrap-Up (10 minutes)
   o Watch all of the music videos!

Figure 4. Scratch Greeting Card
Lesson 7: Hovering Contraptions

Overview: This lesson introduces the students to aeronautical or aerospace engineering by having them make hovering contraptions to float in the wind tunnel.

Learning Goals:
1. Students will be able to explain what aeronautical engineers do.
2. Students will apply the engineering design process in its entirety.
3. Students will practice their interpersonal skills by working in pairs/groups.

Materials:
- large plastic tube about 2’ in diameter and 3’ tall
- box fan
- an assortment of building materials: plastic containers, scrap paper, paper clips, coffee filters, string, tape, cardboard, straws, etc.
- LEGO mini figures (1 per pair)

Lesson Plan:
1. Introduction (5 minutes)
   - Introduce aerospace engineering.
2. Main Activity (45 minutes)
   - The the students must design a hovering contraption that floats in the wind tunnel.
   - Present the materials and ask the groups to draw a quick sketch of their idea on scrap paper. When their idea is complete, groups may ask for materials. They can certainly ask for more or different materials later on, but make sure one STOMPer monitors the materials so that they are distributed fairly and used wisely.
   - Encourage frequent retesting and design. Challenge the students to improve from the first trial to the last.
3. Wrap-up (5 minutes)
   - Discuss some of the important take away concepts: aeronautical engineering, the engineering design process and/or drag, air resistance. It’s up to you to decide what is important for your students.

Modifications: Some classes work well when there is a competition, others become distracted and unproductive. If your class works well when driven by competition, tell the students that the team whose hovercraft floats longest is the “winner.” Distributing prizes is not recommended. For less competition, have each group compete against themselves to make their hovercraft float longer during the last trial than the first.
Lesson 8: Ramp Rollers

Overview: This lesson introduces students to mechanical engineering by having them complete the Ramp Rollers activity.

Learning Goals:
1. Students will be able to describe what environmental engineers do.
2. Students will practice applying all steps of the engineering design process.

Materials/Preparation:
- LEGO pieces for each pair: at minimum: 1 medium plate, 3 different pairs of wheels, 6 axles (varying sizes), 12 bushings, 15 beams (varying sizes).
- a ramp (cardboard, wood, poster board)
- measuring tape
- scratch paper for planning
- other building materials

Lesson Plan:
1. Introduction (5 minutes)
   - Ask the class about mechanical engineers and discuss what they do.
2. Main Activity (50 minutes)
   - Tell the students that they will be building “ramp rollers” (not necessarily a car). The goal of this activity is to get the ramp roller to travel as far as possible before friction stops it. You may consider requiring that the vehicle must carry a LEGO mini-figure, otherwise groups may just attach two wheels with an axle and be done.
   - Have the students discuss with their partner the design of their roller and draw out a sketch. Once finished, give the students their materials.
   - Encourage frequent testing and redesign.
3. Wrap-Up (5 minutes)
   - Discuss: What were some characteristics their roller needed to go far? Did you redesign your roller at all? Why? How? If you had more time and more materials, how would you change your design?

Modifications: Bring in gears for each group and have the students make a roller that goes a very short distance. Bring in weights and have groups experiment with adding weight to their car. Be sure to have them record their observations!
Lesson 9: Ear Trumpets

Overview: In this final lesson of the unit students will design hearing devices (See References for the activity source) to help partially deaf people and learn about biomedical engineering.

Learning Goals:
1. Students will be able to describe what biomedical engineers do.
2. Students will practice applying all steps of the EDP.
3. Students will practice working in teams and collaborating

Materials/Preparation:
• building materials: cardboard, plastic cups, paper towel/toilet paper rolls, plastic tubing, plastic soda bottles, plastic sheets, scissors, tape

Main Activity:
1. Introduction (5 minutes)
   o Introduce biomedical engineering.
2. Main Activity (40 minutes)
   o Talk about hearing loss and what it means to be deaf. Then explain that some people are partially deaf.
   o Have the students brainstorm devices that might help a person hear.
   o Once they have made a plan, they may request materials from one of the STOMPers. Let the students build.
3. Wrap-Up (15 minutes)
   o During the last 15 minutes, review the big ideas that you want the students to be left with. Do a fun review activity of all the different types of engineering such as a modified jeopardy game.
   o Have the students reflect on the unit: What was their favorite part? Least favorite part? What was difficult? What was surprising? What are the big ideas that they will remember from STOMP? It may be more suitable for your group to do a free write (see References).

Modifications: If there are any hearing impaired students in your classroom, talk to the teacher and/or student the week before the lesson to make sure that the student feels comfortable with the activity—they may even want to be involved in a special way. If not, you can do the Protect that Pill activity (see References).
Setting classroom norms
Setting classroom rules may seem unnecessary, but it will really help throughout the semester! Take the extra 5 minutes at the beginning of the unit. It will make it easier for you to correct bad behavior in later classes by referring back to the rules/norms.

One simple and effective way to create norms is by asking kids to complete the sentence “Good engineers...” Be sure that they answer positively. For example, “Good engineers give positive feedback to their partners.” instead of “Good engineers don’t criticize each other.”

Human Robot
Human Robot is a fun way to introduce students to the concept of programming. There are a number of ways to lead the activity. Here is one example: one of the STOMPers pretends to be a robot. The other STOMPPer should help the students “program” him/her to complete a task in the classroom. The task can be anything from putting on socks and shoes (props required) to picking up an item and throwing it in the trash can. Be sure that the students are specific in a way that is comparable to programming.

Scratch
Scratch is an online program that is used to teach students how to program graphically. Get familiar with the program and make sure you are able to do everything that you are asking of your students. Scratch can be found here: http://scratch.mit.edu/.

Ear Trumpet
TeachEngineering.org:

Free Write
A free write can be a fun closure activity that gives the STOMPers a written record of their students’ responses to STOMP. It is also a good way to get feedback from shy students and those students that would otherwise not share in class.
Write a question on the board for example “What surprised you about STOMP?” Pass out scrap paper. Ask the students to write their answer for to the question for 5 minutes without stopping. Start the timer! If they cannot think of anything to write, they may draw. The important thing is that they keep their pencils moving. Ask a few students to share out.

Protect that Pill
Visit this link for a full description of the activity:
Image Bibliography

Figure 1. Plastic Bottle Water Filter
http://www.hometrainingtools.com/media/images/art/WaterFilt_1.jpg

Figure 2. Squishy Circuit

Figure 3. Scratch Greeting Card
http://scratch.mit.edu/projects/10402076/#editor

Figure 4. Ramp Roller

Figure 5. Ear Trumpets