Prosthetics Engineering Design Challenge

How might the Engineering Design process be used to create a prototype to help someone with a limb difference button their shirt?

Many times, the solution to a problem involves designing a product (like a machine or computer code) that meets certain criteria and/or accomplishes a certain task. This process is different from the steps of the scientific method, which you may be more familiar with. If your project involves designing, building, and testing something, you should probably follow the Engineering Design Process. The Engineering Design Process is a solution-based approach to solving problems—from the very simple to the very complex. The approach is non-linear and iterative. It is very common to design something, test it, find a problem, and then go back to an earlier step to make a modification or change to your design.

Limb differences can be caused by a variety of factors, including genetic mutations, genetic syndromes, trauma, infections, or unknown causes. While the exact cause is often unknown for congenital limb differences, they can sometimes be inherited or occur as part of a broader genetic syndrome affecting other parts of the body. Trauma, fractures, or infections can lead to deformities by damaging growth plates or bones, resulting in length discrepancies or malformations.

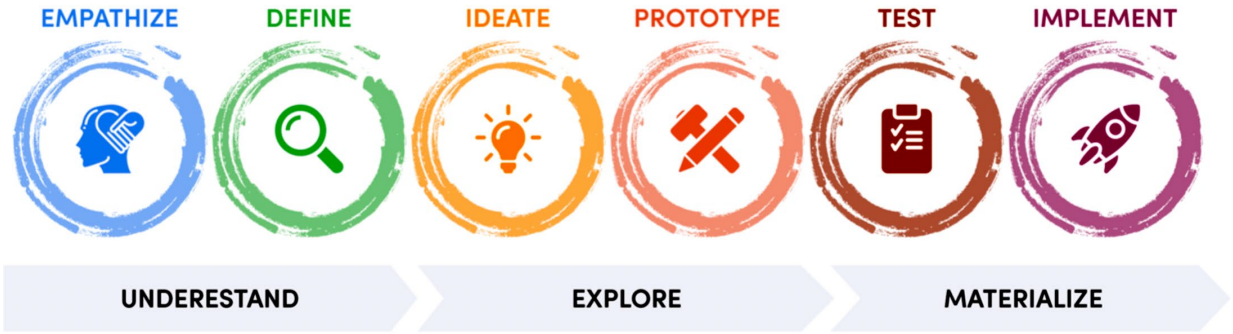
Ohio standards

Engineering and Science Technologies

- 5.1.1. Describe the role of research, development and experimentation in design problem-solving.
- 5.1.2. Conduct an investigation to identify customer needs, constraints and criteria.
- 5.1.3. Develop multiple solutions and select an approach.
- 5.1.4. Develop a design proposal and make a model/prototype.
- 5.1.5. Evaluate and redesign a prototype using collected data.

Student prior knowledge

Students should have a basic understanding of the engineering design process used to solve a problem.



Suggested timeline

Two 40- to 50-minute class periods

Materials

- Men's front-button shirts (1 per group of 3–4 students)
- Craft supplies: scissors, tape, cardboard, glue, tape, string, yarn, etc.
- Large pieces of paper or graph paper for drawing designs

Teacher preparation

Be ready to provide information to students about limb differences and their causes, either with reliable internet links or brochures from various organizations that aid people who have limb differences.

Procedure

1. Review the Engineering Design process.
2. Ask students if they know anyone with a limb difference. Describe what that is and the different ways they can occur.
3. Empathize: Have students tie their shoes using only one hand.
    - How did they feel?
    - Could they do it?
    - What would have helped them?
4. Show students the video at ***youtu.be/X3q0NCGdjmY***, by an Ohio company, FORM5 Prosthetics, which makes a variety of tools to help people with limb differences have a higher quality of life.
5. Share the following scenario: A young boy, 8, has a limb difference and as a result, he cannot use his left hand. He will be attending a summer camp, and he wants to button his own shirts without asking for help.
6. Guide groups of 3–4 students through the design process to make a prototype.
   Notes: Set a time for the ideate phase to end. It may be helpful to designate a person as the tester for all prototypes. FORM5 is a custom designer of tools for helping individual people. One size will not fit all.
    - **Empathize:** Try to button the shirt you have been given. (If there are left-handed folks in your group, they will need to act as if it is their right hand that has a limb difference).
    - **Define:** What specifically is needed to help the person?
    - **Ideate:** What tool or adaptation might meet the need defined? Have students identify the greatest need in the step above; if not, revisit. If so, what is the right tool? It may be helpful to design on paper or create small examples to communicate their ideas to the group. It is easy for the group to split off into individuals during this phase. Walk around and ask them to get ideas about what they are trying from their other group members to see if it is meeting the need they defined above. This process is cyclical and will rotate back and forth between steps to get to the "best solution." However, there is a time limit, so groups should have a design in mind by the end of 45 minutes.
    - **Prototype:** How does it work? Build a prototype of the design. Iterate the design as things don't work or need improvement.
    - **Test:** Try out the design… go back to iterating to "tweak" the design.
    - **Implement:** Ask other members from other groups to try the prototype.
    - Present your tools to the class.

Suggested wrap-up

Lead a discussion with all or ask students individually to answer the questions below, then share out.

1. What was the hardest part of the process? The easiest?
2. Was their design successful?

Differentiation

Students may be grouped cooperatively or in pairs. Mix students with physical impairments or limb differences into groups.

Extensions

Have students design for different activities, such as sports (hockey, baseball) or creative activities such as holding a crayon or paint brush.

Support information

- Form5 Prosthetics: Innovation That Empowers
  form5.org
- Congenital limb differences in children, causes and treatments
  nationwidechildrens.org/conditions/health-library/congenital-limb-difference-in-children
- The 5 stages of the design thinking process
  - *interaction-design.org/literature/article/5-stages-in-the-design-thinking-process*
  - *sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-process-steps*

Career connections

- **Prosthetics Designer:** designs medical support devices and measures and fits patients for them. These devices include artificial limbs (arms, hands, legs, and feet), braces, and other medical or surgical devices.
- **Biomedical Engineer:** applies engineering principles to medicine and biology to design, develop, and evaluate new products and processes that improve health and healthcare, such as artificial organs, prosthetics, diagnostic tools, and medical software.
- **Robotics Engineer:** writes software for device control, develops real-time applications, and collaborates with cross-functional teams to ensure the functionality, safety, and compliance of prosthetic devices.
- **Physical Therapist:** help individuals learn to use, maintain, and adapt to their prosthetic limb to regain strength, balance, and mobility.