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HANDS-ON ACTIVITY

## Design Step 3: Brainstorm Possible Solutions

### Quick Look

**Grade Level:** 9 (9-12)

**Time Required:** 1 hour

Although the time required to complete this design loop step is flexible, realize that students often get caught up in the brainstorming/idea generating process and never move to actual idea selection if not monitored by the teacher.

**Expendable Cost/Group:** US \$1.00

**Group Size:** 4

**Activity Dependency:**

[Design Step 2: Research the Problem](#)

**Subject Areas:** Science and Technology

**NGSS Performance Expectations:**

[HS-ETS1-2](#)

### Summary

Brainstorming is a team creativity activity that helps generate a large number of potential solutions to a problem. In this activity, students participate in a group brainstorming activity to imagine possible solutions to their engineering design challenge. Students learn brainstorming guidelines and practice within their teams to create a poster of ideas. The posters are used in a large group critiquing activity that ultimately helps student teams create a design project outline. (Note: Conduct this activity in the context of a design project that students are working on; this activity is Step 3 in a series of seven steps that guide students through the engineering design loop.)

*This engineering curriculum aligns to Next Generation Science Standards (NGSS).*



Students reflect upon the ideas generated during their team's brainstorming session.

## Engineering Connection

Brainstorming is a helpful technique for group projects, especially for teams needing to break out of the same pattern of thinking and develop a new way of viewing something. Engineering teams are usually composed of a diverse mix of individuals, including engineers with expertise in different disciplines, as well as other professionals. Brainstorming allows teams to tap into all the expertise in the group to develop the most successful solution to a design challenge. Some engineering companies specialize in brainstorming unique solutions to design challenges.

## Learning Objectives

**After this activity, students should be able to:**

- Describe and apply the "rules" of brainstorming.
- Use brainstorming as a technique to generate a large number of ideas.

## Educational Standards

- › [NGSS: Next Generation Science Standards - Science](#)
- › [International Technology and Engineering Educators Association - Technology](#)

## Materials List

**Each group needs:**

- 1 large sheet of butcher paper or white paper, ~ 4 x 4 ft (~1 x 1 m) in size
- a few different colored markers
- [Brainstorming Guidelines Handout](#)

**For the whole class to share:**

- magnets or strong tape to hang the large sheets of paper in the classroom
- 2-3 pads of sticky notes, in two different colors

- o Overhead projection of [Brainstorming Guidelines Handout](#)

## Worksheets and Attachments

[Brainstorming Guidelines Handout \(docx\)](#)

[Brainstorming Guidelines Handout \(pdf\)](#)

Visit [[www.teachengineering.org/activities/view/cub\\_creative\\_activity3](https://www.teachengineering.org/activities/view/cub_creative_activity3)] to print or download.

## Introduction/Motivation

(Have an overhead transparency of the [Brainstorming Guidelines Handout](#) ready to display in a prominent place in the classroom, or else make copies of the guidelines to use as handouts.)

By this point, you should have a good understanding of your design challenge. You and your team have worked to define the problem, identify the project's constraints and requirements, and complete some background research.

Now, let's begin the process of thinking about solutions to the design challenge. To do this, engineers often use a technique called "brainstorming." Brainstorming is a team creativity activity that helps you generate a large number of potential solutions to a problem or challenge. It can be helpful when you need to break out of the same pattern of thinking and develop a new way of looking at something.

When we are working to first come up with ideas, we want to keep open minds and encourage all ideas — even if they don't seem realistic. We want to withhold criticism of our ideas and those from our team members. Also, when we brainstorm, we are striving for quantity of ideas, not quality. Think of it like you are dragging a big net through the ocean in hopes of catching a king salmon. While a big net scoops up many little fish in the process, it also improves your chances that you will find your main prize!

Brainstorming is meant to encourage creative thinking; however, some basic ground rules make it more successful. Let's take a look at these before we divide into our groups for some team brainstorming. (Show the brainstorming guidelines by overhead projection or handout.)

Who has heard the expression "focus on quality — not quantity"? Most of the time you do want to focus more on the quality of your work and less on how fast you can complete it. Brainstorming, in contrast, asks you to focus on quantity, not quality. The purpose is to collect as many ideas as possible, even if they seem ridiculous. We do this because often, wild ideas lead to the most innovative designs. Later in the design challenge you will have time to focus on the quality and practicality of your design.

Remember to record all of your ideas; you do not want to forget an idea that could become useful later. Also, build on the ideas of others. It is good to work together as a team to develop a possible solution, instead of selecting one person's idea. In engineering, the best ideas are generally a team

effort. Sometimes, this can start a snowball effect of additional ideas, so remember to stay focused on the design problem you are working on right now; you will have time to explore other ideas once you have finished working on this one.

Most importantly, when you are brainstorming, remember to withhold criticism of any ideas, including your own. Don't worry about saying something that seems silly or unrealistic. Silly ideas can lead to excellent creative design solutions!

(Note: After conclusion of this activity, proceed to the next activity in the series, [Design Step 4: Select a Promising Solution Using Engineering Analysis](#).)

## Procedure

### Background

Brainstorming is a group creativity technique used to generate a large number of ideas for the solution to a problem. The process itself can boost morale, enhance work enjoyment, and improve team dynamics. Suggested **brainstorming guidelines** include:

1. **Focus on quantity:** The first ground rule is to focus on quantity. You want to capture as many ideas as you can — even if they seem silly.
2. **Withhold criticism:** Not only should you refrain from criticizing the ideas of others, you should make sure not to criticize your own ideas as they emerge during the brainstorming process.
3. **Encourage wild ideas:** We know from experience that (with a bit of reworking and refinement) wild ideas usually lead to the most innovative designs.
4. **Record all ideas:** During a brainstorming session it is helpful to designate a person on your team to write down each idea as it is thrown out. Sentence structure, spelling and grammar do not matter for this list, so wait until later to review or edit anything you write down. Just make sure to capture all the ideas.
5. **Combine and improve ideas:** In the midst of brainstorming, try to build upon the ideas of others. Think of your brainstorming session as a snowball rolling down a "mountain of ideas." Initially, the snowball is small, but it quickly grows and gains momentum as it travels down the hill. The best ideas in engineering are generally a team effort.
6. **Stay focused on topic:** Although brainstorming is meant to be creative and free flowing, make sure you focus your ideas on the topic at hand. This helps you later when you are organizing all the ideas generated in the brainstorming session.

Teams in which students are unfamiliar with each other may show apprehension toward sharing ideas and "letting loose" in a brainstorming session. Remind students that brainstorming is a time to be creative, and even silly! Use the questions suggested in the **Investigating Questions** section to help groups break the ice and make sure the brainstorming ground rules are followed.

### Before the Activity (Teacher Prep)

1. Cut several large sheets of paper, one sheet per team.
2. Gather markers, sticky notes, and magnets or tape.
3. Use the attached [Brainstorming Guidelines Handout](#) to make an overhead transparency and/or copies to use as handouts for each team.
4. Student teams should continue with the same 3-5 members each, as determined in the first activity of this unit, [Design Step 1: Identify the Need](#).

**With the Students: Introduction & Set-Up**

1. Introduce the concept of brainstorming by leading the Introduction/Motivation section.
2. Use the [Brainstorming Guidelines Handout](#) to review the brainstorming ground rules.
3. Lead the pre-activity assessment (as described in the Assessment section) to help students capture the design challenge in a specific question. This exercise asks students to reflect on their design project and develop one question that captures the essence or basics of the design challenge.

**With the Students: Team Brainstorming**

4. Give each team a big piece of paper and a few markers.
5. Ask teams to write their specific design challenge question from Step 3 (above) across the top of their papers.
6. Initiate the brainstorming process by reviewing the brainstorming techniques presented in the overhead transparency or handout (and the Procedure-Background section).
7. Invite teams to begin brainstorming with words or quick sketches using their poster-sized paper and markers.
8. Direct students to write and draw legibly and large enough so their sketches and annotations will be able to be seen by the rest of the class from the front of the room.
9. Give the teams ~20 to 30 minutes to brainstorm. Encourage them to cover the paper with ideas.
10. If teams become stuck, ask them to jot down opposites or jot down things that are only slightly related. Just keep them moving and associating.
11. When time is up, ask teams to cluster their ideas by circling terms that seem related and drawing lines between the terms.
12. Have teams continue the clustering process until they have created associations among most terms. Some terms may be left un-circled, but might still be useful.
13. Ask teams to use magnets or tape to hang their brainstorming posters on a classroom wall or the chalkboard.

**With the Students: Class Brainstorming**

14. Give each person several sticky notes in two colors. For example, if the class is composed of six teams, give each student five blue sticky notes and five pink sticky notes.

15. Indicate that the blue sticky notes are to be "ideas I like," and the pink sticky notes are to be "questions or suggestions for improvement."
16. Ask each team to come to the front of the room and explain their brainstorming posters to the rest of the class.
17. After each team has presented, ask students to "roam the room" and look at each others' posters to find ideas they like and identify a question or suggestion for improvement.
18. Ask students to write these comments on the sticky notes and post them on the other teams' brainstorming papers *at the spot where the idea or concept is written*.
19. Once everyone has finished posting their sticky notes, have each team reflect on the feedback they received via the sticky notes, as described in the activity embedded assessment (see the Assessment section).
20. Have students save their brainstorming posters with comments so they may refer to them as the project progresses.
21. Lead the post-activity assessment (as described in the Assessment section) with the students. In this activity wrap up, students prepare outlines that incorporate the brainstorming data into larger ideas. These ideas may also be recorded in paragraphs to begin a first draft of a design description.

## Vocabulary/Definitions

*brainstorming*: A team creativity activity with the purpose to generate a large number of potential solutions to a design challenge.

## Assessment

### Pre-Activity Assessment

**Capture the Challenge:** It helps facilitate the brainstorming activity if the class, as a whole, first arrives at a common understanding of the design challenge. Ask teams to spend a few minutes defining the design challenge in their own words. Write each team's response on the board and then work with the students to combine ideas to come up with **one question** that captures the essence or basics of the design challenge. For example, our example project on designing prosthetics might ask:

- How can we design a prosthetic hand to perform one mechanical function using simple materials (such as wood, plastic tubing, bendable metals and various adhesives)?

### Activity-Embedded Assessment

**Team Reflection:** Once teams are finished giving each other feedback using the sticky notes, ask them to write answers to the following questions on the backs of their brainstorming posters.

1. Where are most of the "ideas I like" sticky notes concentrated on your brainstorming poster? The ideas and concepts that other students liked are \_\_\_\_\_.
2. Where are most of the "questions or suggestions for improvement" sticky notes concentrated? The ideas and concepts that need further development are \_\_\_\_\_.

### Post-Activity Assessment

**After the Storm:** Ask teams to start filling in the gaps between the ideas they have just brainstormed. Have students prepare an outline that incorporates as much of the brainstorming data that seems logical. Have them also start to write out some larger groups of sentences or full paragraphs to expand upon the smaller clusters and phrases. Suggest they quickly sketch some descriptions if that better illustrates their ideas. From this, they can start to write larger sections of first draft descriptions of their designs. Remind students that they do not have to start at the "beginning" of their brainstorming sequence. Encourage them to focus on the section that comes together most easily.

## Investigating Questions

Use these questions as a "warm up session" or to break the ice with unfamiliar team members and make sure the **brainstorming** ground rules are understood.

- If your team were asked to design the perfect cell phone, **what would it be like?** (Possible discussion points: How would it look? What size would it be? What would be its features? Would these vary, depending on the target audience?)
- Imagine the school has just been awarded a large amount of money to build something new or to create a new program. **What facilities or program would benefit students most?** (Possible discussion points: Is there anything that this school is currently missing? Do any existing facilities or programs need major improvement? How many students would be impacted by the suggested ideas? How would you determine what would benefit the students most? How could you get input from the entire student body in deciding the new facility or program?)

## Troubleshooting Tips

Be alert for team problems with brainstorming, such as distraction and evaluation apprehension. Discourage criticism of ideas. Remind students that in brainstorming, no idea or suggestion is "silly." All ideas should be respectfully heard. This is the time to be uncritical and build on each others' ideas.

When creativity begins to taper during a brainstorming session, a teacher or facilitator can stimulate creativity by asking the group questions such as: "What if you combine these ideas?" and "Can you rank these ideas from silliest to most serious?"

Students often get caught up in the brainstorming/idea generating step of the engineering design loop and never move to actual selection of one idea, so monitor their progress and keep them moving towards this goal.

## Activity Extensions

*Practice, Practice!* It is always good (and fun!) to have students practice brainstorming ideas in teams. For a quick warm-up activity or to fill extra time at the end of a class period, give student teams a hypothetical design challenge to brainstorm for 10 minutes. Then, have them share some of their solution ideas with the class. Some example challenges include a bedroom security system, a new desk organizer, an improved backpack, etc.

## Additional Multimedia Support

IDEO is a worldwide engineering design and innovation consulting firm, known for digging deep and creatively to find unique solutions to design challenges. See more at <https://www.ideo.com/>. Show students the motivating eight-minute NBC Nightline segment on IDEO's innovation process (see brainstorming and use of sticky notes around minute 4) as they redesign a shopping cart at: <https://www.youtube.com/watch?v=M66ZU2PClM>.

## References

- Yowell, J.L. and Carlson, D.W., Eds., *Introductory Engineering Design: A Projects-Based Approach*, Third Edition, Textbook for GEEN 1400: First-Year Engineering Projects, Integrated Program, College of Engineering and Applied Science, University of Colorado at Boulder, Fall 2000. Accessed April 8, 2010. [http://itll.colorado.edu/index.php/courses\\_workshops/geen\\_1400/resources/textbook/](http://itll.colorado.edu/index.php/courses_workshops/geen_1400/resources/textbook/)

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## Supporting Program



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