STEM Challenge: Vacuum Victory

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Time Frame 250 minutes

Essential Question(s)

- How can we use the engineering design process to solve real world problems?

Summary

In this activity, students design and build a model vacuum cleaner or component that demonstrates suction, airflow, or efficiency. They will plan, test, and revise prototypes, learning the value of iteration and collaboration in engineering solutions.

Learning Goals

Attachments

- 3-2-1—STEM Challenge.docx
- 3-2-1—STEM Challenge.pdf
- Activity Slides—STEM Challenge—Vacuum Victory.pptx
- Engineering Design Process Poster—STEM Challenge .docx
- Engineering Design Process Poster—STEM Challenge .pdf
- Engineering Notebook Materials—STEM Challenge.docx
- Engineering Notebook Materials—STEM Challenge.pdf
- Facilitator's Guide—STEM Challenge .docx
- Facilitator's Guide—STEM Challenge .pdf
- My Checklist—STEM Challenge.docx
- My Checklist—STEM Challenge.pdf

Materials

- Activity Slides (attached)
- Facilitator Guide handout (attached; teacher copy)
- Engineering Notebook Materials handout (attached; one per student; optional)
- 3-2-1 handout (attached; one half-page per student)
- My Checklist handout (attached; one per group)
- Engineering Design Process poster (attached; optional)
- Sticky Notes and Chart or poster paper (optional)
- Markers (optional)
- Composition Notebook (one per student)
- Pen/pencil
- Materials for STEM Activity:
    - Small containers or bins (2 per group for sorting materials or testing suction), Measuring cups or spoons (1 set per group), Small battery-operated fans (1 per group), Straws (10 per group), Paper or lightweight foam (10 sheets per group), Cardboard (2 sheets per group), Tape (1 roll per group), Rubber bands (10 per group), Cotton balls or small beads (20 per group for suction testing), Scissors (1 per student), Ruler or measuring tape (1 per group), Glue sticks (2 per group)

25 minutes

Question

Facilitator's Note: STEM Challenge Collection

The following activity is only part of a STEM Challenge Collection, which consists of a variety of possible STEM related activities. We recommend starting with the Engineering Explorers, which is an introduction to the engineering design process as it will best prepare students for the flow of each additional activity.

Facilitator's Note: Scaffolding

Students will need each step of the Engineering Design Process (EDP) to be scaffolded for the first few activities. Students should become more independent as they practice the EDP and will require less teacher-directed instruction. Once students are comfortable with the process, you can update the question and criteria over time to scaffold their learning and ensure alignment as they grow and advance.

Use the **Activity Slides** to facilitate the following STEM Challenge session. Transition through **slides 2-4** to introduce the activity title, essential question, and learning objective. The essential question should be the guiding force throughout the activity and can help shape your probing questions as needed. Move to **slide 5** which shows how students should set up the first sections of their notebook. If you are using the provided **Engineering Notebook Materials** handout, pass one copy out to every student along with scissors and tape or glue. Give students time to set up the Question & Brainstorm sections of their notebooks.

Display **slide 6**. Introduce the scenario for this session to the students and remind them to fill in that part of their notebooks. Read through the slide content in as much detail as needed.

Transition to **slide 7** and explain the criteria for this engineering challenge to students in as much detail as you think necessary.

Display **slide 8**. Using the KWHL Graphic Organizer strategy, have each student go to or create their own KWHL chart in their notebooks by writing the following questions at the top of four columns:

1. Know: What do I know about the task?
2. Wonder: What do I not know (and want/need to know) about the task?
3. How: How will I find the information I need to complete the task?
4. Learn: What have I learned about the task?

Guide students through the **K** (What I Know) section by encouraging them to share prior knowledge, experiences, and assumptions related to the problem without judgment. Then, move to the **W** (What I Want to Know) section, prompting them to generate focused, curiosity-driven questions that highlight gaps in understanding. Allow students time to work.

Next, move to **slide 9** and have students interact with their notebooks by creating their initial hypothesis or prediction based on their K and W responses. Remind students that this initial prediction will be revised and revisited often throughout the engineering design process.

Facilitator's Note: Pacing

By the end of this phase, students should have a clear picture of the challenge and an initial list of questions.

30 minutes

Brainstorm

Display **slide 10** and revisit the KWHL chart introducing the **H** (How I Will Learn) section. Guide students to think about specific strategies they can use to find the answers to their **W** questions. This may include online research, hands-on experiments, interviews with experts, reviewing data, or consulting books and credible websites. Encourage students to match each question with at least one method or resource, considering the reliability and accessibility of their sources. With these strategies in mind, students should begin generating and sharing potential solutions to the problem, using their **K** and **W** entries as a springboard for idea creation. All ideas are recorded without judgment in the space after their KWHL charts to promote creativity and ensure a wide range of possibilities for the next phase of planning.

As students are wrapping up their Brainstorming phase, transition to **slide 11** and remind students to revise their predictions based on the new knowledge gained. Explain that in the real world, scientists do this all the time. A well-trained scientist isn't someone who's always right the first time—they're someone who's willing to update their ideas as new evidence appears. Changing your mind isn't a mistake; it's part of the process and how real discovery happens.

Facilitator's Note: Pacing

During this phase, focus on helping students connect their **W** questions to actionable research strategies in the **H** section of the KWHL chart. Encourage them to think beyond simple internet searches. Consider experiments, direct observation, interviews, and reference materials. Reinforce that brainstorming is a judgment-free zone where creativity is valued over immediate solutions. Your role is to facilitate an inclusive environment where all voices are heard and ideas are recorded. Students will use those ideas to find potential solutions.

55 minutes

Plan and Design

Display **slide 12,** which shows how students should set up the next sections of their notebook. Give students time to set up the Plan & Design sections of their notebooks.

Move to **slide 13**. Explain that now students will review their brainstormed ideas and select the most promising option or combination of ideas that best meet the problem's criteria and constraints. Students will draw detailed sketches and model their design, either physically, digitally, or both, to clearly show how the solution will be built.

Facilitator's Note: Optional Tech Modifications

If relevant, consider allowing students to practice using some of the following tech tools to aid in designing their models:

- Canva
- Figma
- Tinkercad

Something to consider when using a tech option is that students may need a refresher on how to calculate scale and ratios.

The plan should include labeled diagrams, a materials list, precise dimensions or measurements, and a step-by-step process for construction. Emphasize clarity—anyone who reads the plan should be able to understand and replicate the design. This phase bridges creative ideas with practical action, ensuring that the concept is ready for the build phase.

As students are wrapping up their Plan & Design phase, transition to **slide 14** and remind students to revise their predictions based on the new knowledge gained.

Facilitator's Note: Pacing

In this phase, guide students to evaluate ideas critically against the original problem statement, criteria, and constraints. Encourage them to combine elements from multiple ideas if it strengthens the design. Model how to create clear, labeled drawings and accurate models, and reinforce the importance of including all necessary measurements and materials. Support students in thinking through the feasibility of their design, considering safety, resource availability, and construction steps before moving forward.

55 minutes

Build and Create

Display **slide 15**, which shows how students should set up the next sections of their notebook. Give students time to set up the Build & Create sections of their notebooks.

Display **slide 16**. Using their completed plan, students begin building the first version of their design: the prototype. They should follow their drawings, models, and step-by-step instructions carefully, using tools and materials safely and responsibly. While building, students should document their progress through photos, notes, or sketches to capture changes or adjustments made along the way. The goal is to create a testable version of the solution, knowing that it may require improvement in later phases.

As students are wrapping up their Build & Create phase, transition to **slide 17** and remind students to revise their predictions based on the new knowledge gained.

Facilitator's Note: Pacing

During this phase, ensure students have access to all necessary materials, tools, and workspace. Reinforce safety procedures and proper tool use before building begins. Encourage students to reference their plan frequently and to problem-solve when unexpected challenges arise. Remind them that prototypes do not have to be perfect—they are meant to be functional enough for testing and analysis. Provide guidance and troubleshooting support while enabling students to take ownership of their build process.

55 minutes

Test and Analyze

Display **slide 18,** which shows how students should set up the next sections of their notebooks. Give students time to set up the Test & Analyze section of their notebooks.

If students need a reminder, return to slide 7 to review criteria again. Display **slide 19**. As a group, brainstorm and determine what a collection tool (i.e. table or graph) might look like. If needed, model what data would look like within your chosen tool.

Invite students to put their prototype to the test, using the criteria and constraints from the Question phase as their guide. Testing should follow a consistent process so that results are reliable and measurable. Students should gather data through observations, measurements, and feedback, looking for evidence about how well the design performs and where it might fall short. The purpose of this phase is to learn from the prototype, not to prove it's perfect.

As students are wrapping up their tests and data collection, transition to **slide 20** and explain that now they need to brainstorm the best mode for representing their collected raw data for analysis. If needed, review the examples on the slide. Allow students time to brainstorm the best tools for displaying their data. Consider checking in on their ideas periodically.

After students have completed their tables, move to **slide 21** and remind them to write up their analysis more fully in their notebooks. They can use the variables table to outline what variables their experiment(s) yielded and what they would change in the future.

As students are wrapping up their Test & Analyze phase, transition to **slide 22** and remind students to revise their predictions based on the new knowledge gained.

Facilitator's Note: Pacing and Scaffolding

Before testing begins, help students review the original criteria so that they know exactly what success looks like. Provide clear testing procedures and make sure they are applied consistently for all groups. Encourage students to collect both quantitative data (numbers, measurements) and qualitative data (observations, feedback). Ask probing questions like, "What does your data tell you about the design?" or "What patterns do you notice?" This will prepare them to make informed improvements in the next phase.

If additional scaffolding is required, consider a whole class examination of possible collection tools.

25 minutes

Reflect and Improve

Display **slide 23** which shows how students should set up the next sections of their notebook. Give students time to set up the Reflect & Improve sections of their notebooks.

Display **slide 24**. Students review their test results and analysis to determine how well their prototype met the criteria and constraints. Using their collected data, they identify specific strengths to keep and weaknesses to address. Students then propose targeted changes to improve the design, considering materials, measurements, features, or construction methods. Remind students that the goal of this phase is to make the design more effective, efficient, and reliable before retesting or final presentation.

Display **slide 25.** Have students return to their KWHL charts and direct them to complete the "L" column: "What I learned."

Facilitator's Note: Pacing

Guide students to base their improvement decisions on evidence rather than guesswork. Ask questions like "What change would give you the biggest improvement for the least effort?" or "Which weakness is most important to fix first and why?" Encourage them to prioritize changes that directly address test results. Remind students that this phase is part of the iterative nature of engineering. Each cycle makes the design stronger. If time allows, support them in creating an updated plan, drawing, or model before rebuilding. Ideally, students should cycle through these last three phases multiple times.

30 minutes

Communicate

Display **slide 26** and have them brainstorm the best medium to present what they now know. Invite students to reflect and plan how they would communicate their experience.

Display **slide 27** and announce to students that they have been selected to share their findings at the annual Spark Expo. Have them brainstorm the best medium to present what they now know. Invite students to reflect and plan how they would communicate their experience.

Facilitator's Note: Scaffolding

Encourage students to choose a communication format that best fits their audience and resources. This could include slide decks, posters, videos, written reports, demonstrations, or even digital portfolios. Remind them that strong communication isn't just about the final product; it's about showing their thinking, decisions, and problem-solving skills along the way. Consider adding opportunities for peer-review and feedback during practice presentations to strengthen clarity and delivery.

Resources

- K20 Center. (n.d.). 3-2-1. Strategies. https://learn.k20center.ou.edu/strategy/117
- K20 Center. (n.d.). Canva. Tech Tools. https://learn.k20center.ou.edu/tech-tool/612
- K20 Center. (n.d.). Elevator speech. Strategies. https://learn.k20center.ou.edu/strategy/57
- K20 Center. (n.d.). Figma. Tech Tools. https://learn.k20center.ou.edu/tech-tool/3756
- K20 Center. (n.d.). Glow and grow. Strategies. https://learn.k20center.ou.edu/strategy/4962
- K20 Center. (n.d.). KWHL graphic organizer. Strategies. https://learn.k20center.ou.edu/strategy/127
- K20 Center. (n.d.). Plus delta chart. Strategies. https://learn.k20center.ou.edu/strategy/2904
- K20 Center. (n.d.). SWOT. (Strengths, weaknesses, opportunities, threats). https://learn.k20center.ou.edu/strategy/4056
- K20 Center. (n.d.). Tinkercad. Tech Tools. https://learn.k20center.ou.edu/tech-tool/2166