STEM Stories: If I Built a House

Lesson Plan

STEM Career Connections: Architecture and Construction, Civil Engineering

STEM Disciplines: Science, Technology, Engineering & Mathematics

Non-STEM Disciplines: English Language Arts

Design Challenge Problem/Scenario:

You have finally earned enough money to build the house of your dreams near a Florida beach. There are hurricanes and tropical storms often along the Florida beaches and many other coastal cities along the eastern and southern shore lines in the United States. Therefore, you want to make sure your structure is built to withstand the destructive forces of a hurricane's wind, rain, and hail.

Engineering Design Challenge:

Your team's challenge is to build the house of your dreams that can withstand the destructive forces of a hurricane's wind, rain, and hail.

Essential Question Students Investigate:

What makes a house made out of craft sticks, straws, and/or cards strong enough to withstand the destructive forces of wind, rain, and hail?

Enduring Understandings:

- Using the engineering design process when approaching problems results in unique solutions.
- The ability of a force to move an object is dependent on the object's mass and stability.

English Language Arts Standards:

- RL.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
- RL.3.3 Describe characters in a story (e.g., their traits, motivations, or feelings) and explain how their actions contribute to the sequence of events.
- RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
- RI.3.4 Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 3 topic or subject area.
- W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons
- SL.3.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacherled) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly.

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- SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.
- SL.3.6 Speak in complete sentences when appropriate to task and situation in order to provide requested detail or clarification.

Science Standards:

Science Inquiry and Applications, Technological and Engineering Design
During the years of PreK to grade 4, all students must develop the ability to:

- Plan and conduct simple investigations
- Employ simple equipment and tools to gather data and extend the senses
- Communicate about observations, investigations and explanations
- Review and ask questions about the observations and explanations of others
- Identify problems and potential technological/engineering solutions
- Understand the design process, role of troubleshooting

Grade 1: EARTH AND SPACE SCIENCE: Sun, Energy and Weather

- The physical properties of water change.

Grade 1: LIFE SCIENCE: Basic Needs of Living Things

- Living things survive only in environments that meet their needs.

Grade 2: EARTH AND SPACE SCIENCE: The Atmosphere

- The atmosphere is made up of air.
- Water is present in the air.
- Long- and short-term weather changes occur due to changes in energy.

Grade 2: PHYSICAL SCIENCE: Changes in Motion

- Forces change the motion of an object.

Grade 5: PHYSICAL SCIENCE: Light, Sound, and Motion

- The amount of change in movement of an object is based on the mass of the object and the amount of force exerted.

Mathematics Standards:

- Represent and interpret data. CCSS.MATH.CONTENT.3.MD.B.4 Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units--whole numbers, halves, or quarters.
- Use place value understanding and properties of operations to perform multi-digit arithmetic. CCSS.MATH.CONTENT.3.NBT.A.2 Fluently add and subtract within 1000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction.
- Use place value understanding and properties of operations to perform multi-digit arithmetic. CCSS.MATH.CONTENT.3.NBT.A.2 Multiply one-digit whole numbers by multiplies of 10 in the range 10-90 (e.g., 9 x 80, 5 x 60) using strategies based on place value and properties of operations.
- Represent and solve problems involving multiplication and division. CCSS.MATH.CONTENT.3.OA.A.1 Interpret products of whole numbers, e.g., interpret 5 x 7 as the total number of objects in 5 groups of 7 objects each.
- Represent and solve problems involving multiplication and division. CCSS.MATH.CONTENT.3.OA.A.1 Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurement

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quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem.

- Multiply and divide within 100. CCSS.MATH.CONTENT.3.OA.C.7 Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division (e.g., knowing that 8 x 5 = 40, one knows 40 ÷ 5 = 8) or properties of operations. By the end of Grade 3, know from memory all products of two one-digit numbers.

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Material List:

Material	Quantity per Team	✓	Quantity per Kit	✓
Combine following supplies in a baggie			10 baggies	
Play-Doh	1 small tub or stick		10 small tubs or sticks	
Painters Tape	1 yard		2 rolls	
Glue Sticks or Bottles	1		10	
Craft Sticks	16		160	
Deck of Cards	6 cards		60 cards	
Straws	20		200	
Waxed Paper	1 square foot (approx.)		1 roll	
Cardstock	1 sheet		10 sheets	
Paper *(For individual brainstorming)*	1 sheet		25 sheets	
Paper *(For team design sketch)*	1 sheet		10 sheets	
Fan or Blow Dryer *(For testing)*	~		1	
Cups for Water and Beans *(For testing)*	~		2	
Tub or Bin *(To catch water and beans during testing)*	~		1	
Container or Jug *(for holding water used in testing)*	~			
Beans *(For testing)*	~		1 bag	
Memory Stick *(With PowerPoint and handouts)*	~		1	
Pre-Activity Survey	~		35 copies	
Post-Activity Survey	~		35 copies	

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Activity 1

Introduction: 15 minutes

- Sit in a chair and gather the students on the floor around you so they can all see the book.
- Introduce yourself.
- Describe the full scope of the Engineering Challenge (Activity 1, Activity 2, Activity 3, etc.).
- Introduce *If I Built a House* by Chris Van Dusen by reading the title and author and examining the cover illustration.

Pre-Reading: 10 minutes

Lead a pre-reading discussion by asking the following questions of the students:

- Predict: Look at the cover. What is different about Jack's house and your own? What is similar?
- What can you infer, or guess at, using the clues from the cover?

Read Aloud: 20 minutes

Read the book aloud to the class, making sure to share the illustrations on each page. Stop periodically to ask the students to share what they are learning about how Jack builds his dream house.

Throughout the read-aloud, you can use the following strategies to monitor the students' comprehension of the story:

- Ask students a question about the story, then ask them to "turn and talk" to their neighbor to answer the question. Be sure to set a signal for when students should stop their conversation and come back to the large group (hand clapping, snapping, etc.). Questions you might ask include:
  - What is your favorite part of Jack's house? Why?
  - Are all of Jack's creations possible? Why or why not?
  - What are some of the problems with having a house like Jack's? What are some of the benefits?

Post Reading: 15 minutes

Sometimes people who dream big dreams like Jack get made fun of at first, but later on become famous for their creations. Dayton is well known for its architects, inventors, builders, artists, etc. who went on to do amazing, unique things in their lives.

Prior to the lesson, you posted the Inventor posters around the room. Place the students in small groups, and ask them to walk from poster to poster, reading the description and responding on the "graffiti wall" near each poster. This is a piece of chart paper, or a whiteboard area, that can be written on. Students record their responses to the Inventor's story. For example, they might write, "Wow!", "Amazing!", or "How did he think of that?". They might also draw a response, rather than writing it. Allow 7-10 minutes for this activity.

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When students are finished, have a brief discussion with the large group about what they learned.

Wrap Up: 5 minutes

Review what was learned during today's session.

- Invite a retelling of the book by asking students to share what happened first, second, third, and so on in the story.
- Review the inventors and inventions discussed.
- Explain that tomorrow students will be using notebooks to begin documenting their work, and will be starting a new project.

Activity 2

Introduction: 15 minutes

- Sit in a chair and gather the students on the floor around you so they can all see the book.
- Show students text from activity 1 (*If I Built a House* by Chris Van Dusen).
- Complete a picture walk of the book and invite students to state what they remember of the story.
- Relate the book to the inventor posters → have students complete a turn and talk about one thing they remember from the gallery walk about the inventors/architects.

Quick Write: 15 minutes

Distribute the STEM journals to the students (composition notebooks). Direct them to write their name on the front cover of the book, then turn to the SECOND page of the book (the first page will become a table of contents for the journal). Ask them to write the date at the top of the page, and *Entry #1: Building a House*.

Ask them to respond to one of the following writing prompts in their journal (teacher should select one ahead of time). Students can respond in writing, illustrations, or both.

- Would you want Jack as a friend or neighbor, why or why not?
- What are the careers that have to do with houses? If you could have any of these jobs, which would you choose and why?
- A lot of what Jack dreams up are fun, fantastical inventions, but technology is an important part of having our houses built and running smoothly. Name several technologies at work in your house that make your life easier and explain your reasoning.

Set a timer for 10 minutes (www.online-stopwatch.com/) and ask the students to write for the full ten minutes. Tell them to keep their pen moving the whole time, even if they are illustrating their response.

When the ten minutes are up, invite the students to find a partner (or you can identify the partners) to share their writing. Then, invite the students to the large group and ask

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students to share their responses if they wish (and as time allows).

Application: 20 minutes

- Display slide 1 of the PowerPoint: Ask the students to share some ideas about what engineers do for their jobs.
- Slides 2 & 3: Continue the discussion about what engineers do for their jobs.
- Slides 4 & 5: Present the Design Challenge Problem. Be sure to explain to the students that they will build their house the next session and will begin plans to build their house today.
    - Design Challenge Problem:

      You have finally earned enough money to build the house of your dreams near a Florida beach. There are hurricanes and tropical storms often along the Florida beaches and many other coastal cities along the eastern and southern shore lines in the United States. Therefore, you want to make sure your structure is built to withstand the destructive forces of a hurricane or tropical storm's wind, rain, and hail.
- Slide 6: Discuss the Engineering Design Challenge.
    - Your team's challenge is to build the house of your dreams that can withstand the destructive forces of a hurricane's wind, rain, and hail.
- Slide 7: Explain the design goals.
    - Build a house to withstand the forces of wind, rain, and hail.
    - Use only the materials that are available.
    - Build a house in the given time.
    - Build a house on wax paper.
    - Build a house with a length, width, and height less than 6 inches.
    - Build a house with both walls and a roof.
- Slide 8: Introduce the resources/materials available for each team. The teacher should show each of these items to the class.
    - Play-Doh, painters tape, glue, craft sticks, cards, and straws.
- Slide 9: Explain the design testing procedures.
- Slide 10: Explain the Engineering Design Process.
    - Give students the Engineering Design Process Graphic Organizer STEM Challenge handout and the If I Built A House: Ask, Imagine, and Plan handout.
- Slide 11: Have the students complete the "Ask" step of the Engineering Design Process.
    - Ask the students to notice that the word Ask is in one of the circles of the Engineering Design Process.
    - Students should Ask themselves what materials they would like to use to build a house that can withstand wind, rain, and hail. Students should write these materials on their STEM Challenge handout.
    - Walk around as the students complete the Ask step of the Engineering Design Process.
- Slide 12: Explain to the students that the next time they meet, they will spend time on the Imagine step in the Engineering Design Process. In fact, you can ask students to start imagining what their house will look like when they are at home, and they can share their ideas with their families.

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Wrap Up: 5 minutes

- Remind the students of the Engineering Design Challenge.
- Preview the next session by explaining to students that they will continue the Engineering Design Process so that they can imagine and plan to build their house.
- Distribute the parent letter to each student.

Activity 3

Introduction: 5 minutes

- Remind the students that during the previous session they reviewed and discussed the book *If I Built a House* by Chris Van Dusen and were presented with a Design Challenge Problem and Engineering Design Challenge. Generate a discussion about the Design Challenge Problem and Engineering Design Challenge.

Engineering Design Process, Imagine and Plan: 20 minutes

- Display slide 12 of the PowerPoint:
  - Ask the students to notice that the word Imagine is in one of the circles of the Engineering Design Process both on the PowerPoint and on the If I Built a House: Ask, Imagine, and Plan handout.
  - Students should Imagine what their houses will look like.
  - Students should draw a picture or write a description of their house on their STEM Challenge handout.
  - Walk around as the students complete the Imagine step of the Engineering Design Process.
- Slide 13:
  - Ask the students to share their ideas with their team.
  - Walk around as the students share their ideas with their teammates. Make sure that each student is given ample time to share his or her ideas. Students get excited about wanting to build the houses and often rush through the sharing process. Remind students that the sharing process is extremely important as engineers often alter their designs based on ideas shared during the brainstorming process.
- Slide 14:
  - Ask the students to notice that the word Plan is in one of the circles of the Engineering Design Process both on the PowerPoint and on their If I Built a House: Ask, Imagine, and Plan handout.
  - Students should Plan as a team what their house will look like.
  - Students can use a teammates' ideas or a combination of the teams' ideas, but remind them that they must create one house together as a team!
  - Students should draw a picture or write a description of their house on their STEM Challenge handout.
  - Walk around as the students complete the Plan step of the Engineering Design Process.
  - Make sure all students are contributing to the planning process. Often the dominant students expect the other students to use his or her ideas. Remind students that coming to a team consensus is important as engineers are

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often expected to plan with a group of people.
    - Ask students probing questions about their houses:
        - How did you combine your individual design ideas?
        - Why did you choose that design?
        - How did you create the idea for this design?
        - What are your reasons for selecting the material for your house?
        - Suppose a company decided to use your team's ideas for an actual house they plan to build. How sturdy do you think their house would be if wind, rain, and hail hit their house?
    - Before allowing teams to build their houses, require them to gain approval of their sketch of the team's prototype design idea. You can write "Approved" beside the sketch on a student's paper or hand them a note card with "approved" written on it. A colored note card works nicely as you can easily see if a team has the note card on their desk or table before they begin to work with the materials.

Engineering Design Process, Create: 30 minutes

- Slide 15: Ask the students to notice that the word Create is in one of the circles of the Engineering Design Process both on the PowerPoint and on their If I Built a House: Ask, Imagine, and Plan handout. Then, ask them to draw a picture on the STEM Challenge handout of the house they plan to create.
- Remind students of the Design Goals:
    - Build a house to withstand the forces of wind, rain, and hail.
    - Use only the materials that are available.
    - Build a house in the given time.
    - Build a house on wax paper.
    - Build a house with a length, width, and height less than 6 inches.
    - Build a house with both walls and a roof.
- Distribute the If I Built a House: Create Your House! handout, and ask the students to keep track of the materials they use to build their house.
- As the students are building their prototypes, walk around the room and ask them probing questions about their design. For example:
    - What are your reasons for selecting that material?
    - What are your reasons for using that material for a wall?
    - What are your reasons for using that material for a roof?

*Note: It is most likely that the house built out of cards will be the best design. The Play-Doh is best used when packed in the bottom of the houses as a foundation to the structure.

Wrap Up: 5 minutes

- Ask students to place their handouts and materials in a safe location and to clean up their area.
- Distribute the parent letter to each student.

Activity 4

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Introduction: 10 minutes

- Remind students that last time students completed the Engineering Design Challenge.
- Ask students how their process relates to the book *If I Built a House*.
    - Exemplar: Jack imagines and built a house, and we did the same thing!
- Ask students what steps they took to design and build their houses.
    - Exemplar: "First we had to *Ask* a question, which was how can we build a house to withstand wind, rain, and hail. Next, we had to *imagine* how we could do this. After that we planned our house and talked with our teammates to make the best possible model, and finally we created our house using Play-doh, cards, glue, and craft sticks."
- Today, students will calculate the cost of the materials they used to build their house, measure the dimensions of their house, and test their house to see if it can withstand wind, hail, and rain.

Calculate Cost of Materials: 15 minutes

- Slide 16: Give each student the If I Built a House: Cost of Materials handout.
    - Explain that each team will calculate the cost of their home. First, each team must determine the cost of a few materials.
- Slide 17: Have the students calculate the cost of the glue.
    - If two containers of glue cost $1.50, what is the cost of one container of glue?
    - Walk around as the students discuss how to calculate the cost of the glue. Allow students to use any strategy to calculate the unit price. Listen to students share their strategies so that you can ask these students to share their strategies during share time.
- Slide 18: Have the students calculate the cost of one craft stick.
    - If four craft sticks cost $1.00, how much does one craft stick cost?
- Slide 19: Have the students calculate the cost of one tub of Play-Doh.
    - If eight tubs of Play-Doh cost $4.00, what is the cost of one tub of Play-Doh?

Share Time: 5 to 10 minutes

- Slide 20: Ask the students to share how they calculated the cost of one glue, one craft stick, and one tub of Play-Doh.

Prototype Testing: 30 minutes

- Slide 21: Each team tests their prototype house while other teams observe.
    - The houses will be tested in a bin so that the water and beans are contained. Place the house in a bin and first start with wind. Turn the blow dryer to high, and hold it directly over the house to see if the house falls apart. If the house passes this test, move on to testing if the house will withstand hail. Take a cup filled with dried beans and pour it on top of the house. If the house does not fall apart, move on to testing if the house will withstand rain. Fill a cup with water and pour it over the house. If the house is still standing still without any destruction, the house design is successful.

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- Celebrate each team's design by having the class applaud for that team after that team shares their design.
- Students should complete the If I Built a House: Test and Improve Your House handout.

Wrap Up: 5 min

- Have students reflect on something they learned from the prototype testing (turn and talk)
- Preview next lesson by telling students that tomorrow they will make plans to improve their house and then build a second house

Activity 5

Introduction: 5 minutes

- Slide 22: Show the students the book, *If I Built a House*, and ask them to raise their hands and offer a one-sentence summary of the book. Invite as many one-sentence summaries as time allows. Alternatively, ask the students to turn to a partner and tell a one-sentence summary of the book. Remind students that they are working on building a house, just like Jack built a house in the story.
- Slide 23: Ask the students to respond to the second journal prompt. Be creative - students can draw or write!
- Help teams of students locate their handouts and materials.
- Remind the students that during the previous session they calculated the cost of some materials and tested their house to see if it could withstand wind, hail, and rain. Explain that students will be reflecting on this activity as a group
- Today, students are going to make plans to improve their house; and build a second house.

Reflection: 5 minutes

- Ask students to read to themselves their responses on their If I Built a House: Test and Improve Your House handout.

Engineering Design Process, Improve: 5 minutes

- Slide 24: Ask the students to notice that the word Improve is in one of the circles of the Engineering Design Process both on the PowerPoint and on the If I Built a House: Ask, Imagine, and Plan handout. Students should discuss how they can Improve their house. Ask students to discuss with their team:
  - What do you like best about your house?
  - What would change about your house?
  - What aspects of other team designs stood out to you?
  - Did other designs give you ideas for ways to improve your design?
  - What modifications would you make if we had time to complete the design challenge again?
  - How did the materials affect the ability for the house to withstand the forces applied to them?
- Students can use a teammates' ideas or a combination of the teams' ideas, but remind them that they must create one new, stronger house together as a team!

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- Students should draw a picture or write a description of their house on their STEM Challenge handout.

Buying Time!: 15 minutes

- Students work as a team to decide what materials they want to purchase to create a house. The materials are on the If I Built a House: Buying Time! handout. Students should use the table in the handout to record the number of each item they want to purchase, the cost associated with each item, and the total cost of all items.
- Walk around the room as the students discuss the materials they would like to purchase.
- Once a team is ready to purchase their materials, have them tell you the cost of the materials they would like to purchase and the change they should receive.

Teams Build Their Houses: 30 minutes

- Slide 26: Ask the students to notice that the word Create is in one of the circles of the Engineering Design Process.
- Remind students of the Design Goals:
    - Build a house to withstand the forces of wind, rain, and hail.
    - Use only the materials that are available.
    - Build a house in the given time.
    - Build a house on wax paper.
    - Build a house with a length, width, and height less than 6 inches.
    - Build a house with both walls and a roof.
- As the students are building their homes, walk around the room and ask them probing questions about their design. For example:
    - What are your reasons for selecting that material?
    - What are your reasons for using that material for a wall?
    - What are your reasons for using that material for a roof?

*Note: It is most likely that the house built out of cards will be the best design. The Play-Doh is best used when packed in the bottom of the houses as a foundation to the structure.

Wrap Up: 5 minutes

- Ask students to place their houses in a safe location and clean up their area.
- Ask the students if they have any ideas as to what type of engineer might design houses.
    - If a teacher or student assistant has built a home or done something similar, possibly through co-op or a class project, share the experiences (in simple terms) with the students.

Activity 6

Introduction: 5 minutes

- Help teams of students locate their handouts and materials.
- Remind the students that during the previous session they built their second house.
- Today, students are going to measure the length, width, and height of their house; test their house against wind, hail, and rain; and reflected on why their house did or

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did not withstand the wind, hail, and rain tests.

Teamwork, Measuring Dimensions of House: 15 minutes

- Slide 27: Distribute to each student a copy of If I Built A House: Measure Your House handout.
- Discuss the meaning of the words, measure, inches, centimeters, length, width, and height. Distribute the Math Vocabulary handout and ask students to individually write the words they know well enough to teach to someone else, words they have heard before, and words they do not know at all in the appropriate columns.
- Walk around as the students share their responses with their teammates. If talking to their teammates helps them understand the word more, they can move it to a different column on their chart by crossing out the original and writing it again in the new column. For example, if the student put a word in the "I've heard of it, but do not know a meaning" column, she can move it up if their team reminds them of the meaning and she knows it well because of the conversation.
- If needed, have a class discussion about the meaning of length, width, and height to clarify the meanings for all students.
- Ask the students to measure the length, width, and height of their house.

Prototype Testing: 30 minutes

- Slide 28: Each team tests their prototype house while other teams observe.
    - The houses will be tested in a bin so that the water and beans are contained. Place the house in a bin and first start with wind. Turn the blow dryer to high, and hold it directly over the house to see if the house falls apart. If the house passes this test, move on to testing if the house will withstand hail. Take a cup filled with dried beans and pour it on top of the house. If the house does not fall apart, move on to testing if the house will withstand rain. Fill a cup with water and pour it over the house. If the house is still standing still without any destruction, the house design is successful.
    - Celebrate each team's design by having the class applaud for that team after that team shares their design.
    - Students should complete the If I Built a House: Test and Improve Your House handout.

Wrap up: 5 minutes

- Have students reflect on something they learned from the prototype testing their second structure.
- Tell students that the next lesson will be the last day of the unit and that they will be reflecting on the design project.

Reflection: 25 minutes

- Slide 29: Distribute the sentence stems and ask the students to paste them on the next page in their journal. Ask them to write the date at the top of the page and number the entry. Sentence stems can be removed to differentiate the lesson for different abilities.
- Ask students to first respond to these questions in their journals and then discuss answers with their team.

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    - What do you like best about your house?
    - What would change about your house?
- Lead a class discussion, inviting students to share their responses. Have students "think-pair-share" to the questions below to expand the discussion. Advanced students can respond to these additional questions in their journals, as well.
    - What aspects of other team designs stood out to you?
    - Did other designs give you any ideas for ways to improve your design?
    - What modifications would you make if we had time to complete the design challenge again?
    - How did the materials affect the ability for the house to withstand the forces applied to them?

Wrap Up: 30 minutes

- Discuss text-to-self, text-to-text and text-to-world connections with the students. Put the Text Connections handout on the overhead or Elmo machine so all students can see it and explain each type of connection.
- If time allows, read the story, *If I Built a House* again. As you read, ask the students to make text-to-self, text-to-text or text-to-world connections between what they hear in the story and how they built their house. Ask them to keep track of their connections using tally marks for each connection on a blank copy of the handout, which can be pasted into the STEM journal as an additional entry.
- Stop periodically throughout the story to share your own connections as a model, then invite students to share their connections. Remind them of the importance of using "textual evidence" to make their connections. Ask, "What sentence or picture in the story helped you make that connection?"
- (Optional Writing Activity): Ask students to write a one paragraph summary of their connections to the story and the STEM challenge in their STEM notebooks.
- Slide 30: Conclude by discussing the following questions as post-activity surveys are distributed.
    - What ideas do you have for engineering a better world?
    - How can you turn ideas into reality?
- Allow time for students to complete their post-activity survey.

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