

STEM Stories: Emmanuel's Dream

Lesson Plan

STEM Career Connections: Mechanical Engineering and Health Sciences

STEM Disciplines: Science, Technology, Engineering and Mathematics

Non-STEM Disciplines: English Language Arts

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.
- W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons.
- 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 2: PHYSICAL SCIENCE: Changes in Motion

- Forces change the motion of an object.

Grade 4: PHYSICAL SCIENCE: Electricity, Heat and Matter

- Energy can be transformed from one form to another or can be transferred from one location to another.

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.

This material is based upon work supported by the Engineering Science Foundation of Dayton under Grant No. AD2018-0001 and through a 2017-18 grant from the Marianist Foundation.

- 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 multiples of 10 in the range 10-90 (e.g., 9×80 , 5×60) 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 5×7 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 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 $8 \times 5 = 40$, one knows $40 \div 5 = 8$) or properties of operations. By the end of Grade 3, know from memory all products of two one-digit numbers.

Design Challenge Problem/Scenario: You have a friend with limited hand and wrist muscle strength and control, making the simple daily task of putting on socks difficult. You know there has to be a way to help your friend solve this problem. Perhaps you can make a device that will help them put on their socks.

Engineering Design Challenge: Pulling on a sock is difficult for people with limited hand and wrist muscle strength and control. It is a struggle for their muscles to overcome the sock's elastic potential energy when stretched, and gravitational potential energy when lifted. Your challenge is to use only the materials available to design and build a device prototype that can help people pull on their socks independently.

Essential Question Students Investigate: How can we design and engineer an assistive device that helps someone with limited hand and wrist muscle strength and control put on socks?

Enduring Understandings:

- Using the engineering design process when approaching problems results in unique solutions.
- Collaboration and following the engineering design process lead to more creative and effective solutions to problems.

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- All energy can be put into two categories: kinetic and potential; each form can be transferred to another place or object. An object in motion has kinetic energy. Energy in an object that is “waiting” to happen (to be put into motion) is the object’s potential energy.
- Stretchy objects can store elastic potential energy but you have to do work to give them that stored potential energy.
- Objects lifted up above the ground gain gravitational potential energy and you have to do work to give them that energy.

Materials List:

Material	Quantity per Team	✓	Quantity per Kit	✓
Paper Clips	2		30	
Rubber Bands	6		90	
Construction Paper	1 sheet		1 pack	
String or Yarn	2 feet		1 ball	
Masking Tape	4 inches		1 roll	
Binder Clips	2		30	
Pipe Cleaners	4		60	
Safety Pins	3		45	
Plastic Forks	2		30	
Craft sticks	3		45	
Mannequin Foot	~		1	
Powerpoint	~		1	
Pre-Activity Survey	~		25 copies	
Post-Activity Survey	~		25 copies	
Post-it Notes OR Paper <i>(For individual brainstorming)</i>	15 Post-its OR 3 sheets paper		2 packs Post-its OR 25 sheets paper	
Paper <i>(For team design sketch)</i>	1 sheet		15 sheets	

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Activity 1

Introduction: 5 minutes

- Sit in a chair and gather the students on the floor around you so they can all see the book.
- Describe the full scope of the Engineering Challenge (Activity 1, Activity 2, Activity 3, etc).
- Introduce *Emmanuel's Dream: The True Story of Emmanuel Ofasu Yeboah* by Laurie Ann Thompson 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: What might the book be about? Where do you think the story takes place? What do you notice about the person on the cover?
- Read the book jacket summary aloud. Ask, What is Emmanuel's disability? What is ability?
- What are some questions you have about Emmanuel before reading this book? What would you like to find out about Emmanuel by reading this book?
- Read the title page. What is the setting of the story? **Share the map of Africa** and point out Ghana, Accra, and Koforidua.

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 Emmanuel and his disability.

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

- Ask them to give a "thumbs up" or a "thumbs down" in response to yes or no questions about the story. For example:
 - Is Emmanuel's village similar to Dayton?
 - Do you think Emmanuel should have moved away from home?
 - Is Emmanuel disabled?
 - Are Emmanuel and his mom alike? Different?
- 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:
 - Describe Emmanuel's village. What clues from the illustrations or the text help you know more about Emmanuel's village?
 - How does Emmanuel see himself?

- What choices does Emmanuel make to accept help when needed?
- Who encourages Emmanuel to be independent in the story? How?

Post Reading: 10 minutes

Discuss what is meant by a “big idea” (it is one of the main ideas of the text). This book has several “big ideas”. Distribute the worksheet to the students, and ask them to work with a partner to determine how each big idea relates to Emmanuel and to their own lives. Discuss with the large group.

*This chart can be pasted into the STEM journal as a way to keep track of the student’s learning throughout the modules. Paste it in before or after the Quick Write (below).

Wrap Up: 10 minutes

Review what was learned during today’s session.

- Invite a retelling of the Emmanuel’s Dream book by asking students to share what happened first, second, third, and so on in the story.
- Review the concepts of Emmanuel’s powerful message and the big ideas from the text.
- Remind the students of the Engineering Design Challenge.
- Preview the next session by explaining to students that they will be working with the materials in the kit to build their prototype next time.

Activity 2

Introduction: 10 minutes

- Remind the students that during the previous session they read and discussed *Emmanuel’s Dream: The True Story of Emmanuel Ofasu Yeboah* by Laurie Ann Thompson
- Today they will be presented with a Design Challenge Problem and Engineering Design Challenge.
- Do a “picture walk” through the book to remind students of the main ideas.
- Remind students that Emmanuel pedaled nearly four hundred miles in ten days. Ask students to determine the average number of miles Emmanuel pedaled each day.

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: Emmanuel’s Dream*.

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.

- How are you similar to and how are you different from Emmanuel?
- Respond to Emmanuel's powerful message, "Disability does not mean inability." What does it mean to you?
- What is a powerful message you would like to spread to the world?

Set a timer for 10 minutes 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 is 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 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.
- Slide 4: Play one of the Christopher Hills youtube videos or something similar to show engineering solutions for people with disabilities.
<https://www.youtube.com/watch?v=cSSgndQ5mVs>
- Slide 5: Present the Design Challenge Problem.
 - Design Challenge Problem: You have a friend with limited hand and wrist muscle strength and control, making the simple daily task of putting on socks difficult. You know there has to be a way to help your friend solve this problem. Perhaps you can make a device that will help them put on their socks.
- Slide 6: Present the Engineering Design Challenge.
 - Engineering Design Challenge: Pulling on a sock is difficult for people with limited hand and wrist muscle strength and control. It is a struggle for their muscles to overcome the sock's elastic potential energy when stretched, and gravitational potential energy when lifted. Your challenge is to use only the materials available to design and build a device prototype that can help people pull on their socks independently.
- Slide 7: Explain or share the Design Goals.
 - Device must help someone pull on a sock
 - Only provided materials can be used
 - Device cannot be attached to sock
 - Have fun!!
- Slide 8: Introduce the resources/materials available.

- Slide 9: Explain the design testing procedures.
 - Attach your device to the sock.
 - Use your device to pull the sock onto provided foot.
 - Use your device to take the sock off of provided foot.
- Slide 10: Explain the Engineering Design Process
 - Give students the Engineering Design Process Graphic Organizer STEM Challenge handout and the Emmanuel's Dream: Engineering Design Process student 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 both on the PowerPoint and the Emmanuel's Dream: Engineering Design Process student handout.
 - Students should Ask themselves what materials they would like to use to build their assistive device for socks.
 - 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 11: 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 product will look like when they are at home, and they can share their ideas with their families.

Wrap Up: 10 minutes

Review what was learned during today's session.

- Invite a retelling of the Emmanuel's Dream book by asking students to share what happened first, second, third, and so on in the story.
- Review the concepts of Emmanuel's powerful message and the big ideas from the text.
- Remind the students of the Engineering Design Challenge.
- Preview the next session by explaining to students that they will be working with the materials in the kit to build their prototype next time.

Activity 3

Set-Up:

- Designate space for displaying and gathering available materials.
- Designate space for each team to collaborate and build their design ideas. Also, make sure all students will be able to see the presentation.
- Designate space for design testing. Make sure there is room for all students to observe.

Introduction: 5 minutes

- Remind the students that during the previous session they read and discussed *Emmanuel's Dream: The True Story of Emmanuel Ofasu Yeboah* by Laurie Ann Thompson 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: 15 minutes

- Display slide 11 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 the Emmanuel's Dream: Engineering Design Process student handout.
 - Students should Imagine what their Assistive Device will look like.
 - Students should draw a picture or write a description of their Assistive Device on their STEM Challenge handout.
 - Walk around as the students complete the Imagine step of the Engineering Design Process.
 - 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 a marble ramp 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.

Engineering Design Process, Plan: 15 minutes

- Display slide 11 of the PowerPoint:
 - 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 the Emmanuel's Dream: Engineering Design Process student handout.
 - Students should Plan as a team what their assistive device will look like.
 - Students can use a teammates' ideas or a combination of the teams' ideas, but remind them that they must create one assistive device together as a team!

- Students should draw a picture or write a description of their assistive device 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 often expected to plan with a group of people.
- Ask the students probing questions about their assistive device designs:
 - 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 assistive device?
 - Suppose a company decided to use your team's ideas for an assistive device that they plan to build. How sturdy do you think the assistive device will be?
- Before allowing teams to build their assistive devices, 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.

Buying Time!: 15 minutes

- Students work as a team to decide what materials they want to purchase to create an assistive device. The materials are on the Emmanuel's Dream: 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.

Engineering Design Process, Create: 30 minutes

- Slide 11: Teams create their assistive devices.
 - 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 the Emmanuel's Dream: Engineering Design Process student handout.
 - As the students are creating their assistive devices, walk around the room and ask them probing questions about their design. For example:
 - Why did you choose those materials for the design?
 - Will the design be strong enough to hold open the sock?

- How challenging is it to put on a sock without hand and wrist strength and control?

Prototype Building - Notes

Students may use only the materials provided. The device must be built separate from the sock. The sock cannot be part of the design; the device must be able to attach to and detach from the sock.

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

Introduction: 10 minutes

- Show the students the book, *Emmanuel's Dream*, 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 an assistive device for putting on socks.
- Help teams of students locate their handouts and materials.
- Remind the students that during the previous session they created an assistive device.
- Today, students are going to test their assistive device.

Assistive Device Testing: 20-30 minutes

- Each team tests their prototype assistive devices while other teams observe.
 - Design will be tested using a mannequin foot. Students must design a device that can be attached to a sock. The device will be used to help someone pull a sock onto the mannequin foot. Have students think about how easy it was to pull the sock onto the mannequin foot, or would it have been easier to their own foot.
 - *Note: the design cannot be built on the sock. It must be something that can be attached during testing and detached after testing.*
 - Celebrate each team's design by having the class applaud for that team after that team shares their design.

Reflection: 10-15 minutes

- Slide 12: Ask students to discuss with their team:
 - What do you like best about your assistive device?
 - What would change about your assistive device?
 - What aspects of other team designs stood out to you?

- Did other designs give you ideas for ways to improve your design?
- What modifications will you make to redesign your assistive device?
- How did the materials affect the ability of the assistive device to withstand the forces applied to them?
- If time permits, ask some students to share their ideas with the entire class.
- Ask the students if they have any ideas as to what type of engineer might work with assistive devices.

Wrap Up: 10 minutes

- Ask students to place their handouts and materials in a safe location and clean up their area.
- Explain that next session students will be redesigning their prototype and testing it again
- Distribute the parent letter to each student.

Activity 5

Introduction: 5 minutes

- Last time we made our initial design, today we are going to redesign our prototype and test it once again.

Assistive Device Redesign and Construction: 30 minutes

- Slide 12:
 - Students use what they have learned testing their designs to modify their assistive devices to make them better.
 - As the students are working on their new designs, walk around the room and ask them probing questions about their redesign. For example:
 - How well did your first design work?
 - Why are you making that change?

Redesigned Assistive Device Testing: 20 minutes

- Each team tests their redesigned assistive devices while other teams observe.
 - Design will be tested using a mannequin foot. Students must design a device that can be attached to a sock right before testing. The device will be used to help someone pull a sock onto the mannequin foot. Have students think about how easy it was to pull the sock onto the mannequin foot, or would it have been easier to their own foot.
 - *Note: the design cannot be built on the sock. It must be something that can be attached during testing and detached after testing.*
 - Celebrate each team's design by having the class applaud for that team after that team shares their design.
 - Students should complete the Emmanuel's Dream: Test and Improve

Your Device handout.

Wrap Up: 20 minutes

- Ask students to place their handouts and materials in a safe location and clean up their area.
- 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, *Emmanuel's Dream* 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 the STEM challenge. 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 the students to write a one paragraph summary of their connections to the book and the STEM challenge in their STEM notebooks.
- Slide 13: 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?
- The Challenged Athletes Foundation (CAF), who Emmanuel wrote to in San Diego, California and who sent him a bike and gear, invited him to participate in the 2002 Triathlon Challenge. In a triathlon, athletes swim, get out of the water and bike, and then get off their bike and run. During the triathlon, Emmanuel took seven hours to complete the 56-mile bike portion. If Emmanuel biked about the same number of miles each hour, how many miles did he bike per hour? While at the triathlon, the Loma Linda University Orthopaedic and Rehabilitation Center offered to perform and pay for Emmanuel's surgery to receive a prosthetic leg. Emmanuel accepted the offer and had the surgery. In the 2003 Triathlon Challenge, Emmanuel lowered his time by three hours. How long did Emmanuel take to finish the 56-mile bike portion and approximately how many miles did he bike per hour?
- Distribute the parent letter to each student.