STEM Stories: Tiny Stitches

Lesson Plan

STEM Career Connections: Health Sciences and Biomedical Engineering

STEM Disciplines: Science, Technology, Engineering and Mathematics

Non-STEM Disciplines: English Language Arts

Design Challenge Problem/Scenario:

Your friend has a farm with pet goats, and one of the goats has eaten something that they should not have eaten. Goats eat the weirdest things! The goat cannot digest the funny thing it ate, so it must be removed from its stomach.

Engineering Design Challenge:

Your team's challenge is to create a surgical instrument that can safely remove an unwanted object from a goat's stomach. You cannot hurt the goat or damage the object. The dominoes will represent the goat's stomach, so be careful not to hurt the goat by knocking over the dominoes.

Essential Question Students Investigate:

How can we create a device that can safely remove an object without harming the surrounding materials?

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.
- The concepts of strength of materials and structural integrity are important for this problem. The design challenge is how to create a device sturdy enough to precisely remove one of the objects from a delicate location without disturbing its surroundings.

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.3.4 Determine the meaning of words and phrases as they are used in a text, distinguishing literal from nonliteral language.
- W.3.3 Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences

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.

- 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: PHYSICAL SCIENCE: Motion and Materials

- Objects can be moved in a variety of ways, such as straight, zigzag, circular, and back and forth.

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 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

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.

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.

Materials List:

Material	**Quantity per Team**	✓	**Quantity per Kit**	✓
Tiny Stitches: The Life of Vivien Thomas by Gwendolyn Hooks	~		1	
Dominoes	~		80	
Empty Copier Paper boxes	~		4	
Straws	6		100	
Masking Tape	6 inches		1 roll	
String/Yarn	1 foot		1 roll	
Plastic Forks	3		70	
Plastic Spoons	2		70	
Paperclips	3		30 count box	
Binder Clips	1		20	
Pipe Cleaners	2		40 count bag	
Wooden Craft Sticks	4		140 count box	
Pencils	2		40	
Clothespins	1		20	
Construction Paper	1 sheet		96 sheets	
Rubber Bands	4		150 count bag	
Styrofoam Cups	1		20	
Cardstock	1 sheet		1 pack	
Post-it Notes **OR** Paper *(For individual brainstorming)*	15 Post-its **OR** 3 sheets paper		2 packs Post-its **OR** 25 sheets paper	
Paper *(For team design sketch)*	1 sheet		15 sheets	

***Will also need testing objects for the contents of the goat's stomach. These objects should be small and lightweight (about two inches or smaller). With four groups, five objects in each stomach IS recommended.**

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.

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.
- Remind the students of the full scope of the Engineering Challenge (Activity 1, Activity 2, Activity 3, etc.).
- Introduce *Tiny Stitches: The Life of Vivien Thomas* by Gwendolyn Hooks by reading the title and author and examining the cover illustration. Briefly review the key vocabulary terms students may hear in the story using the chart in the *Vocabulary Knowledge Handout*. Students can paste this chart into the STEM journals (ENTRY #X, Date). Ask students to write the words into the appropriate column based on their knowledge of the words. Then, ask the students to talk about the words with a partner and see if they can determine a meaning of the words they did not know. Finally, have a group discussion of the words, placing the chart on a document camera. Ask students to look and listen for these words as you read the book.
- Invite predictions about what the design challenge might relate to for this module.

Pre-Reading: 10 minutes

- Before reading the book, introduce the *Question-Answer Relationship (QAR)* strategy by explaining that when we read, we can find two types of information:
    - Information that can be found in the text, and
    - Information that is not in the text but can be found in your own experience and knowledge.
- For each type of information, there are two types of questions. Use the *Question Types Handout* provided to describe these question types, but wait to distribute the handout until after you describe the question types.
    - In the text:
        - Right There: The answer is “right there” in the text. You can put your finger on the answer.
        - Think and Search: The answer is in the text, but you need to move your finger to multiple spots to point to it. You have to think and search the text to find the answer.
    - In your head:
        - Author and Me: You need to use the information in the text, combined with your own experiences, to answer the question. This is an inference.
        - On My Own: To answer this question, rely on your own experiences to form an opinion or perspective related to the text.
- Distribute the *Question Types Handout* to be pasted into the STEM journals.Explain that we will be answering these questions as we read the book together.

Read Aloud: 20 minutes

- Begin reading the book aloud, stopping at the following points to model the different question types and how to find the answers. At each point, read the question, model how you decide what type of question it is, and demonstrate how to find the

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.

answer. Allow students time to write the answers to the questions on their handouts. Alternatively, you can use the differentiated answer strips for students to glue in the appropriate spot on the handout to answer the questions.
    - Right There:
    - Think and Search:
    - Author and Me:
    - On my Own:
- Throughout the read aloud, stop and discuss the vocabulary words you pre-taught at the beginning of the lesson. Encourage students to raise their hands when they hear one of the words in context. Discuss any misunderstandings about their meanings.

Post Reading: 15 minutes

- Review the vocabulary words and ask students to move any of the words they learned more about to a new category on their *Vocabulary Knowledge* rating chart.
- Explain to students that a strategy readers use to monitor their comprehension is summarizing. Explain:
    - A summary does not retell the whole story. Rather, it tells the most important parts of what happened at the beginning, in the middle, and at the end.
- Ask students to brainstorm what happened at the beginning, then the middle, then the end, and record their responses on chart paper or an ELMO.
- Work with the students to narrow their responses to only the most important pieces. Model by thinking aloud as you circle those that are important and strikethrough those that are minor, narrating your reasons. Invite students to contribute to this process.
- Once you have a list of the most important elements of the beginning, middle, and end of the story, ask students to write a summary of the story in their STEM notebooks. They should try to have one sentence for the beginning, one for the middle, and one for the end. Remind students that each sentence should have a capital letter and a period. Differentiate this activity by providing the sentence stems to students who may need support in writing three sentences. Other students can orally tell their summary to an adult who can record their words in the journal.
- Invite students to share their summaries with the class, as time allows.

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.

Activity 2

Quick Write: 15 minutes

- For the *Quick Write*, provide students with one of the following prompts, and invite them to write their responses. Point out to them that these questions are "On My Own" questions because they ask students to form an opinion or response to the story based on their own experiences. Students can write or draw their responses, or a combination of both, depending on their abilities.
    - Vivien Thomas does not receive any of the public recognition for his work. How would you feel if you designed something to help people but didn't receive any of the credit?
    - Vivien Thomas dreams of going to medical school and becoming a doctor. What dream do you have? What will you need to do to achieve your dream?
    - Vivien Thomas feels nervous when he is talking Dr. Blalock through the baby's operation. Have you ever felt nervous before a performance or test? How did you deal with being scared?

Application: 20 minutes

- Display slide one 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.
    - Design Challenge Scenario: Your friend has a farm with pet goats and one of the goats has eaten something that they should not have eaten. Goats eat the weirdest things! The goat cannot digest the funny thing that it ate, so the object will have to be removed from its stomach.
- Slide 6: Present the Engineering Design Challenge.
    - Engineering Design Challenge: Your team's challenge is to create a surgical instrument that can safely remove an unwanted object from a goat's stomach. You cannot hurt the goat or damage the object. The dominoes will represent the goat's stomach, so be careful not to hurt the goat by knocking over the dominoes.
- Slide 7: Explain or share the Design Goals.
    - Create a device capable of retrieving objects from inside the wall of dominoes (goat's stomach).
    - Make sure the device is able to be moved carefully, without knocking over dominoes! *That would be like knocking into the inside of the goat's stomach…OUCH!*
    - Have fun!!
- Slide 8: Introduce the resources/materials available.
- Slide 9: Explain the design testing procedures.
    - Dominoes will be set up around the edge of a box, representing the goat's stomach.
    - The device will have to enter the box, grab, and remove the object eaten by the goat and causing the goat harm (without knocking over any of the dominoes)!
    - Success is measured based on how many dominoes are left standing.

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.

- In the case of a tie, the team that removes the object fastest, while knocking over the least amount of dominoes wins.
- Slide 10: Explain the Engineering Design Process.
- Slide 11: Have the students complete the “Ask” step of the Engineering Design Process.
  - Distribute the Engineering Design Process Graphic Organizer STEM Challenge handout and Tiny Stitches: Engineering Design Process student handout.
  - 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 on the Tiny Stitches: Engineering Design Process student handout.
  - Students should Ask themselves what materials they would like to use to create their surgical instrument.
  - Students should write these materials on their STEM Challenge handout.
  - Walk around as the students complete the Ask step of the Engineering Design Process and query them about their ideas.
- 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 device 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 book by asking students to share what happened first, second, third, and so on in the story.
- Review the inventors and inventions discussed.
- 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 design and create their surgical instrument.

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.

Activity 3

Set-Up:

- Designate space for displaying and gathering available materials.
- Designate space for each team to collaborate and create 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.
- Place five small objects in an empty copier paper box. Place dominoes around the objects in the box. The task the students will be performing is similar to the classic game "Operation".

Introduction: 5 minutes

- Remind the students that during the previous session they read and discussed the book *Tiny Stitches: The Life of Vivien Thomas* by Gwendolyn Hooks and were presented with a Design Challenge Scenario and Engineering Design Challenge. Generate a discussion about the Design Challenge Scenario and Engineering Design Challenge. Do a "picture walk" through the book to remind students of the main idea.

Engineering Design Process, Imagine: 10 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 on the Tiny Stitches: Engineering Design Process student handout.
    - Students should Imagine what their surgical instrument will look like.
    - Students should draw a picture or write a description of their surgical instrument 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 create a surgical instrument 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: 10 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 on the Tiny Stitches: Engineering Design Process student handout.
    - Students should Plan as a team what their surgical instrument will look like.
    - Students can use teammates' ideas or a combination of the teams' ideas, but remind them that they must create one surgical instrument together as a team!

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.

- Students should draw a picture or write a description of their surgical instrument 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 students probing questions about their surgical instrument:
  - 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 surgical instrument?
- Before allowing teams to create their surgical instrument, 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

- Display slide 11: Students work as a team to decide what materials they want to purchase to create a cushioning device. The materials are on slide 11 of the PowerPoint and on the Tiny Stitches: Buying Time! handout. Students should use the table in the student 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: 15 minutes

- Slide 11: Teams create their surgical instrument
  - 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 the Tiny Stitches: Engineering Design Process student handout.
  - As the students are creating their surgical instrument, 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 lift an object without breaking?
    - Will the design be strong enough to lift an object without bending too much?
    - Will the design be precise enough to pick up just one object at a time?

Wrap Up: 10 minutes

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

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.

Activity 4

Introduction: 10 minutes

- Show the students the book, *Tiny Stitches: The Life of Vivien Thomas*, 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 designing and creating a surgical instrument that can safely remove an unwanted object from a goat's stomach.
- Help teams of students locate their handouts and materials.
- Remind the students that during the previous session they created a surgical instrument.
- Today, students are going to test their surgical instrument.

Surgical Instrument Testing: 20 minutes

- Each team tests their prototype surgical instruments while other teams observe.
    - To test the design, have teams use their surgical instrument to retrieve the objects from the box. Record the number of dominoes knocked down. If a team recovers the objects without knocking over the dominoes, the surgical instrument is said to be successful. If all teams successfully recover the objects without knocking over any dominoes, do a timed run.
    - Celebrate each team's design by having the class applaud for that team after that team shares their design.
    - Students should complete the Tiny Stitches: Test and Improve Your Device handout.

Reflection: 10 minutes

- Slide 12: Ask students to discuss with their team:
    - What do you like best about your surgical instrument?
    - What would you change about your surgical instrument?
    - 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 will you make to redesign your surgical instrument?
    - How did the materials affect the ability of your surgical instrument to pick up the objects without knocking over the dominoes?
- 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 design and create surgical instruments.

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.

Engineering Design Process, Improve: 20 minutes

- Slide 12:
    - Students use what they have learned testing their designs to improve their surgical instruments.
    - 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?

Wrap Up: 5 minutes

- Ask students to place their handouts and materials in a safe location and to clean up their area.

Activity 5

Introduction: 10 minutes

- Help teams of students locate their handouts and materials.
- Remind the students that during the previous session they created an improved surgical instrument.
- Today, students are going to test their improved surgical instrument.

Redesigned Surgical Instrument Testing: 20 minutes

- Each team tests their redesigned surgical instruments while other teams observe.
    - To test the design, have teams use their surgical instrument to retrieve the objects from the box. Record the number of dominoes knocked down. If a team recovers the objects without knocking over the dominoes, the surgical instrument is said to be successful. If all teams successfully recover the objects without knocking over any dominoes, do a timed run.
    - Celebrate each team's design by having the class applaud for that team after that team shares their design.

Wrap Up: 20-30 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, *Tiny Stitches,* 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

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.

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?
- Allow time for students to complete their post-activity survey.
- Distribute the parent letter to each student.

Activity 6

Introduction: 5 minutes
Ask students to discuss the size of the stitches that Dr. Viven used for the blue babies.

Investigation!: 30 minutes
Give each student a Tiny Stitches: Investigation! handout.

Students should use the Internet to investigate the following questions:

1) What is the average size of a baby’s heart? Draw a picture to represent the actual size and shape of a baby’s heart.

2) What is the average size of a baby’s artery? Draw a picture to represent the actual size and shape of a baby artery on the heart you drew in #1.

3) Dr. Viven made tiny stitches. Draw these stitches on the picture of the artery to represent the actual size of the stitches.

4) What is the average size of a child’s heart?

5) What is the average size of an adult’s heart?

6) What was the size of the needle Dr. Viven created to make the tiny stitches?

7) In the 1940s, what was the size of a needle used to draw blood? Compare the size of the needle used to make the tiny stitches to the needle used to draw blood.

Sharing Time: 15 minutes
Allow students to share how they answered the Investigation questions.

Wrap Up: 5 minutes
- Ask students to place their handouts in a safe location.

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.