Resource developed by
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Special thanks to
Tucson Electric Power
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Save My House on the Hill (Water under the Bridge)
Civil Engineering Flood Protection Project
(https://stemazing.org/save-my-house-on-the-hill/)

Grades: 2nd Grade & 4th Grade (NGSS – Kinder, 3rd Grade, & 4th Grade)

Arizona Science Standards (NGSS Correlations)

2.E1U2.6 (NGSS-P: K-ESS2-1) ~~**Analyze patterns** in weather conditions of various regions of the world and~~ **design, test, and refine** solutions to protect humans from severe weather conditions.*

4.E1U2.10 (NGSS-P: 3-ESS3-1 & 4-ESS3-2) **Define problem(s)** and **design solution(s)** to minimize the effects of natural hazards.

*Strikethrough text in standard indicates this lesson does not address that part of the standard.

Estimated Time: four one-hour sessions over two weeks

- Session 1 – introduction to engineering using world's best gliders with IDEAS Engineering Journals
    - about a week for aerospace engineers to engineer gliders and civil engineers to play with flood systems
- Session 2 – report on final glider designs, report on noticings and wonderings from playing with the flood system
- Session 3 (next day) – learn about floods and set criteria and constraints for flood protection engineering design challenge
    - about a week for civil engineers to engineer flood protection solutions
- Session 4 – celebration of learning through reports on final flood protection designs to save my house on the hill

#SciencingAndEngineering Teacher Talk with 2nd grade teacher Maddie Schepper and Robot General Sherrie Dennis: http://bit.ly/SandETeacherTalkFloodProject

#STEMAZingPictureBooks

Flood Warning by Katharine Kenah (Illustrated by Amy Schimler-Safford)

- Minimum one copy for the teacher, better one copy per student

Everyday Superheroes: Women in STEM Careers by Erin Twamley and Joshua Sneideman

Materials/Resources (cost is about $10 per flood system kit)

For Each Student (or group of 2-3 if they can share materials):

~40 small craft sticks	~10 chenille stems (pipe cleaners)	1 roll of duct tape
1 plastic paint tray	6 plastic "rain" cups (16 oz)	1 roll of transparent tape
¾ gallon play sand	~25 index cards (ruled, 3"x5")	1 pair of scissors
½ pkg modeling clay	~20' string	1 writing utensil (pen or pencil)
Building blocks (48 pkg)	~20 flexible plastic straws	IDEAS Engineering Journal (2 copies per engineer)
Mop bucket		
5 gal. paint stick		

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Advanced Teacher Preparation

1. The paint trays and rain cups need holes drilled in them.
   - Drill two to three ¼" holes in the middle bottom edge of the paint trays so the floodwaters can drain out into the mop bucket (see flood system setup image for reference).
   - Drill holes in the middle of the bottom of the rain cups. Each of the three colors should have a different sized hole – one color ¼", one color $^{3}/_{16}$", and another color $^{1}/_{8}$". This makes the rain cups graduate from $^{4}/_{16}$" to $^{3}/_{16}$" to $^{2}/_{16}$", respectively.
2. Print and assemble or staple the two copies of the IDEAS Engineering Journal (https://stemazing.org/ideas-engineering-journal/) for the engineers.
3. Flood System Kits need to be put together for each engineer and distributed to engineers.

Leading Questions: What is an engineer? What are some of the different kinds of engineers? How do engineers make the world a better place?
- Reference: https://tryengineering.org/students/engineering-computing-and-technology-fields/

Essential Question: How can we, as civil engineers, protect structures from flooding?

Investigative Phenomenon:

- Video of real house in Oklahoma falling into river due to flood erosion - http://bit.ly/OKhouseFlood
- Video of house on a hill suffering from erosion in model flood system - http://bit.ly/STEMAZingFloodVideo

In-Person Classroom Adaptation

The project detailed below was carried out via remote instruction. It is easily adapted to in-person classroom instruction. Engineers would need to be provided outdoor space at school to set up their flood systems and they need access to water. They could work in groups in-person (if allowed to share materials). In this case, you would just need one setup per two-three engineers. Instead of a week to engineer and explore between Sessions 1 & 2 and 3 & 4, students would need to be provided additional class time to play with the flood system and then design and test flood protection ideas. They could engineer modifications to their gliders at school or at home.

Additional Resources:

- 11-year-old designs a better sandbag, named 'America's Top Young Scientist' http://bit.ly/BetterSandbagBy11yearold
- SCAMPER (https://stemazing.org/scamper-creative-brainstorming/) – another brainstorming tool which engineers can use to spark new modification ideas to supplement the questions provided in the IDEAS Engineering Journal

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Session 1 - Introduction to engineering using world's best gliders with IDEAS Engineering Journals

NOTE: Session 1 Teacher Slide Deck in PPT and Google Slides versions can be found at https://stemazing.org/save-my-house-on-the-hill/

Science and Engineering Practice	**Designing Solutions:** The end-products of engineering are solutions to design problems. The goal of engineering design is to find a solution to problems that is based on scientific knowledge and models of the materials world. During the design process models or prototypes are systematically tested, and iteratively revised based on performance. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.	
Components of SEP **In this lesson, aerospace engineers (students) have a structured opportunity to:**	**Teacher actions taken to facilitate this component for aerospace engineers (students):**	**The aerospace engineers (students) are…**
Describe criteria and **constraints** of a design problem, including quantification when appropriate	• (5 min) Introduction using leading questions about engineers • (10 min) Show Ideas are Scary - GE Commercial (https://stemazing.org/ideas-are-scary-ge-commercial/) and lead discussion about what engineers notice and wonder • (15 min) Lead aerospace engineers through original glider build with flat wings with IDEAS Engineering Journal and testing • (10 min) Lead aerospace engineers through first modification – turning wings into loops with IDEAS Engineering Journal and testing	• tapping into funds of knowledge and adding to their understanding of engineers. • thinking about how we need to be kind to both ideas and people. • building original glider, drawing labeled diagram, and testing performance of glider (not great). • brainstorming modifications based on questions in journal, modifying flat wings into loops, drawing labeled diagram, testing performance of glider, filling out journal with observations and ideas

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	• (10 min) Show Meet Molly – GE Commercial (https://stemazing.org/meet-molly-ge-commercial/) and lead discussion about what engineers notice and wonder. If time, replay video a second time to see what else they catch when seeing it again. Ask what kind of engineer they think Molly is at the end of the video.	• noticing how a young girl (about their age) engineers all kinds of solutions and eventually becomes an engineer. Applying their knowledge of types of engineers to decide Molly might be an aerospace engineer or mechanical engineer or computer engineer.
Apply scientific knowledge to **generate** a design plan that includes consideration for the criteria and constraints	• (10 min) Facilitate use of IDEAS Engineering Journal to brainstorm ideas for second modification and make a labeled drawing of their choice for the next modification they will make. Every engineer can decide upon their own modification to make next.	• deciding upon and drawing labeled diagram of their plan for a second modification, describing modification and why they picked it using IDEAS Engineering Journal.
Build, **test**, and evaluate the design of an object, tool, process, or system	• (about a week) Give aerospace engineers time to test and modify (repeatedly) using IDEAS Engineering Journal including using customer feedback. If there is a chance to touch base and share progress within the week, all the better. Otherwise, nudge engineers to keep working on their designs via online classroom.	• testing their second modification, deciding upon and making additional modifications using the IDEAS Engineering Journal as a reporting tool. They are also making additional modifications and recording their results in the IDEAS Engineering Journal.
Refine and/or optimize the design solution based on performance during testing and consideration of the criteria and constraints	• (about a week – same week as last part) Allow time for aerospace engineers to iterate through making at least five modifications to their design	• making modifications to their glider as they make labeled drawings, describe modifications, test designs, and report on evidence about performance using their IDEAS Engineering Journal.

EXTENDED LEARNING: Beyond refining their aerospace engineer glider designs over their week, the teacher also asks the engineers to start wearing their civil engineer hat. Following directions on Flood Warning Notice and Wonder page (found here: https://stemazing.org/save-my-house-on-the-hill/), they should be instructed to set up their flood systems and play to learn.

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Session 2 – World's Best Glider Final Design and Notice/Wonder Model Flood System Oral Report

1. (30 min) Let each aerospace engineer check in and show off their final glider designs. Ask them questions to help them share their process and thinking. Examples provided below.
    - Can you show us your final glider design?
    - What did you modify about your design to try to make it perform better?
    - How do you know it performs better than the original design?
    - What would you change next if you were to keep making modifications?
2. (15 min) Let civil engineers volunteer to share what they noticed and wondered as they set up their model flood systems.
3. (15 min) Read aloud (using interactive reading techniques) pages 1-11 in *Flood Warning* by Katherine Kenah.

Session 3 – Save My House on the Hill Engineering Design Challenge

House on the Hill setup and engineering design challenge can be found at https://stemazing.org/save-my-house-on-the-hill/

Science and Engineering Practice	**Designing Solutions:** The end-products of engineering are solutions to design problems. The goal of engineering design is to find a solution to problems that is based on scientific knowledge and models of the materials world. During the design process models or prototypes are systematically tested, and iteratively revised based on performance. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.	
Components of SEP **In this lesson, civil engineers (students) have a structured opportunity to:**	**Teacher actions taken to facilitate this component for civil engineers (students):**	**The civil engineers (students) are…**
Describe criteria and **constraints** of a design problem, including quantification when appropriate	• (10 min) Read aloud (using interactive reading techniques) pages 12-19 in *Flood Warning* by Katherine Kenah. • (10 min) Sharing Save My House on the Hill model flood system setup for the engineering design challenge. Calling out constraints and criteria and answering any clarifying questions.	• making connections to what they know and tapping into their funds of knowledge. • identifying the constraints and criteria for their flood protection designs.

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Apply scientific knowledge to **generate** a design plan that includes consideration for the criteria and constraints	• (5 min) Give civil engineers time to build a house using their building blocks and share it with their peers. • (15 min) Lead civil engineers through brainstorming and making a labeled drawing of the first design they will try on the cover of their second copy of the IDEAS Engineering Journal. Answering any clarifying questions about their assignment over the next week to build and test their original design and then make modifications to their design using the IDEAS Engineering Journal as a guide. • (10 min) Read aloud (using interactive reading techniques) pages 20-34 in *Flood Warning* by Katherine Kenah.	• building a model house with their blocks to use in their model flood system. • using their experience playing with the model flood system to come up with an initial design. • making connections to what they know and tapping into their funds of knowledge.
Build, **test**, and evaluate the design of an object, tool, process, or system	• (10 min) Explain their engineering design challenge over the next week is to build their first engineering design, test it, evaluate the design, and decide if they will keep it and make modifications or kick it and try a new idea. The IDEAS Engineering Journal will be their guide. Attention will be drawn to the Fellow Engineer or Customer Critique portion of the journal. Either a classmate can act as a Fellow Engineer or a significant adult, sibling, or other human in their network can serve as customer to look at their design and provide a critique.	(Completed outside of class time if remote or in class time if in-person.) • building their first flood protection design and testing it in their flood system. • using IDEAS Engineering Journal to keep track of modifications, performance, and evaluation of their design. • iterating through the engineering design process five times using the IDEAS Engineering Journal and incorporation an outside critique of their current design.

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Refine and/or optimize the design solution based on performance during testing and consideration of the criteria and constraints	• No further teacher action needed. This will happen as civil engineers work through the IDEAS Engineering Journal.	• using the IDEAS Engineering Journal to guide their flood protection solution design, refine it through multiple iterations, and optimizing it as they test and make modifications in the moment. • reporting their process and modifications, failures and successes in their civil engineering journey to design a flood protection solution for their house on the hill.

Session 4 – Celebration of Learning: Final Flood Protection Engineer Design Oral Report

1. (30 min) Let each civil engineer check in and show off their final flood protection designs for their house on the hill. Ask them questions to help them share their process and thinking. Examples provided below.
    - Can you show us your final flood protection design?
    - What did you modify about your design to try to make it perform better?
    - How do you know it performs better than the original design?
    - What would you change next if you were to keep making modifications?
2. (15 min) Let civil engineers volunteer to share what they noticed and wondered as they attempted to save their house on the hill. Be particularly mindful in calling out how failure is a part of engineering and testing solutions.
3. (15 min) Wrap up with a whip around the room to see if they all liked being an aerospace engineer or a civil engineer better and why. This is also a good opportunity to share more specifics about those careers. #STEMAZingPictureBook Recommendation: *Everyday Superheroes: Women in STEM Careers* by Erin Twamley and Joshua Sneideman – This book has a profile of superhero Vanessa Galvez for "B" – **B**uilding a Green City: Civil Engineer and has a profile of superhero Dr. Danielle Wood for "L" – **L**aunching Satellites: Aerospace Engineer.