**Emergency Storage Container Bid**

Target Grade Level(s): 10th-12th

Subject(s): Algebra II, Geometry, Engineering, Economics

Author(s): Sara Hoorn, Ashley Gossens, Erin Moody

**Problem Statement:**

It seems like every day there is a new global crisis in the news: wildfires in California, hurricanes in the Caribbean, earthquakes in Mexico, and the refugee crisis in Syria. One of many issues in these times is how to get relief to the affected area when the usual methods are not available. What if there was just one product that could be sent to any of these places to provide relief for people?

Your task is to design and fill the interior of a shipping container placed on this campus to serve the staff and students in the event of an earthquake. What will be the most important items in your container? How much will it cost? Once you determine your design, determine what other areas of the world could be helped with your container.

**Unit Overview and Table of Contents**

In terms of content this is a stand alone unit. A class of 24 to 36 students will be divided into two groups. Those groups will then be divided into 4 groups. The individual groups will focus on food/water, communication/emergency management, shelter, and medical response. Each team will determine what is needed in the storage container and how much space it will take up. The large group will then put together a proposal and present it to invited guests to win the contract. Consider who you might be able to invite to speak to your class either in person or by Skype; engineers, disaster preparedness planners, university professors in environmental health sciences, etc.

**Lesson 1: Presentation of Problem**

* Maximize the Space Lab
* Earthquake video
* Brainstorm needs after a earthquake
* Storage Unit visit

**Lesson 2: Finding the Epicenter and Magnitude of an Earthquake**

* Video describing p and s waves.
* Identifying p-s interval and amplitude of s waves.
* Using the p-s interval to find the epicenter on a map and using p-s and amplitude to determine the magnitude.

**Lesson 3: Statement of Work**

* Practice using a decision matrix.
* Maximize the space statement of work and 4 different proposals for that statement.
* Groups then discuss the proposals and their opinions on which is “better”.
* Students are then given the statement of work for this project with an opportunity to ask questions.
* Exit Slip - career interests

**Lesson 4: Brainstorming Techniques**

* Group students by interest based on the exit slip from previous lesson.
* Go through the employability rubric and peer review sheet used to assess each other.
* Go through some different ways to brainstorm as a group - presentation - come up with a couple of problems to present to the class.
* Allow time for groups to begin brainstorming on their particular topic and present their first conceptual design and budget estimate.

**Lesson 5: Packaging lab - how will what is put in the storage pod survive an earthquake**

* Students will design packaging a pringles chip.
* Focus will be on cost and surviving various tests.
* Allow time - (TBD by teacher whether this is in class or outside of class) to allow students to revisit their topic and what packaging may or may not be needed for the disaster pod.

**Lesson 6: Sustainability of Disaster Pod**

* Have students add to their proposal how their disaster pod could be used in other global crisis.
* Students will receive another global crisis to consider and include in their proposal what changes would be needed to occur to address the new crisis.

**Lesson 7: Presentation of Proposals**

* Invite staff to attend the presentation and fill out a decision matrix to determine which business wins the bid.

**Standards (NGSS, CCSS, CTE):**

**HS-ETS1-1 Engineering Design**

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**HS-ETS1-2 Engineering Design**

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

**HS-ETS1-3 Engineering Design**

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

**Standards for Mathematical Practice**

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Look for and make use of structure.
7. Look for and express regularity in repeated reasoning.

**HSG.GMD.A.1-Geometric Measurement and Dimension**

Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone. *Use dissection arguments, Cavalieri's principle, and informal limit arguments*.

**HSG.GMD.A.2-Geometric Measurement and Dimension**

(+) Give an informal argument using Cavalieri's principle for the formulas for the volume of a sphere and other solid figures.

**HSG.GMD.A.3-Geometric Measurement and Dimension**

Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.\*

**HSG.MG.A.1 Modeling with Geometry**

Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).\*

**HSG.MG.A.3 Modeling with Geometry**

Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).\*

*Modeling is best interpreted not as a collection of isolated topics but rather in relation to other standards. Making mathematical models is a Standard for Mathematical Practice, and specific modeling standards appear throughout the high school standards indicated by a star symbol* (\*).

**Soft Skills:**

Communication, Collaboration, Critical Thinking, Information and Technology Literacy, Problem Solving

1.A.1 Use a wide range of idea creation techniques (such as brainstorming).

1.A.2 Create new and worthwhile ideas (both incremental and radical concepts).

1.A.3 Elaborate, refine, analyze, and evaluate their own ideas in order to improve and maximize creative efforts.

3.B.1 Demonstrate ability to work effectively and respectfully with a diverse team.

3.B.2 Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal.

6.A.1 Use technology as a tool to research, organize, evaluate, and communicate information.

8.A.1 Set goals with tangible and intangible success criteria.

8.A.2 Balance tactical (short-term) and strategic (long-term) goals.

10.A.1 Set and meet goals, even in the face of obstacles and competing pressures.

10.A.2 Prioritize, plan, and manage work to achieve the intended result.

**Locally and/or Personally Relevant for Students:**

We live in a region and has been and still is expecting a large earthquake to rock and potentially cripple this area temporarily. It is very possible that the earthquake could occur while on campus and students and staff will have to find ways to communicate with each other and potentially care for each other. The hope is that this scenario of caring for others will pull in female students who maybe did not see a connection between STEM careers like engineering and science and look at careers options in a new light.

**Connections to career and educational pathways:**

Mechanical Engineering, Industrial Engineering, Project Management, Biomedical Engineering, Structural Engineering, Electronics Engineering, Sustainable Engineering, Mechatronics Engineering, Systems Engineering, Manufacturing Engineering, Geological Engineering,

***WABS STEM PBL Unit/Lesson Plan***

**Description:**

Problem-based learning (PBL) is focused, experimental learning organized around the investigation and resolution of messy and real world problems. The Final Unit will allow you to organize your lesson in a problem solving environment where students engage in learning in relevant and connected ways. Teachers function as a coach to guide student inquiry and facilitate learning to deeper levels of understanding for your students.

Research indicates that PBL is a superior pedagogy for promoting student engagement in the learning process. Torp and Sage (2002)1 broaden the impact of this pedagogy and confirm that it increases motivation, makes learning relevant to the real-world, promotes higher order thinking and self-regulated learning in students.

Generally, the teacher will present the problematic situation. The problem is ill-structured and messy (multiple sub-problems), not easily solved and **does not result in one right answer**. Students engage in active problem solving, and teachers guide and coach. A collaborative environment provides for the sharing of information within and between groups as they work to resolve - some may test and re-resolve - their problems. Authentic assessment compliments the problem solving process.

1 Torp, L., & Sage, S. (2002) Problems as Possibilities: Problem Based Learning for k16 Education (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development

**PBL Procedure[[1]](#footnote-0): What is in a PBL Unit?**

Use this page as a reference. The PBL procedure may be one lesson or may be the process throughout whole unit. Lessons may focus on a small part of the procedure or highlight the iterative process needed to get closer to a solution**.**

**Understand The Problem*:*** Describe how you will launch your problem. In this portion of the lesson, students will work towards a common understanding of what the problem is and what they need to know in order to solve the problem.

* Introduction/Problem Launch
* Brainstorm What Students Know/Need to Know
* Define/refine the Problem

**Explore the Problem*:*** How will students’ explore multiple ideas, pathways, and challenge their current conceptions? How will all students access the information/context? The students (groups) will develop multiple solutions to the problem based on their evidence that will be shared in the next section.

* Gather Information
* Share Information
* Generate Possible Solutions

**Resolve the Problem*:*** Students should be able to provide an argument for each of the possible solutions and be given an opportunity to share and critique arguments. How will students reflect upon and share what they’ve learned? How will students synthesize their learning? If there are presentations involved with this PBL, how do you plan to help the non-presenters learn from presentations?

* Determine Best Fit solution
* Present the Solution
* Debrief the Problem

**Lesson 1 - Maximize the Space You Have Been Given**

**Problem statement:**

It seems like every day there is a new global crisis in the news: wildfires in California, hurricanes in the Caribbean, earthquakes in Mexico, and the refugee crisis in Syria. One of many issues in these times is how to get relief to the affected area when the usual methods are not available. What if there was just one product that could be sent to any of these places to provide relief for people?

Your task is to design and fill the interior of a shipping container placed on this campus to serve the staff and students in the event of an earthquake. What will be the most important items in your container? How much will it cost? Once you determine your design, determine what other areas of the world could be helped with your container.

**Learning objectives:**

* Students will design a box, given just one peice of paper, that maximizes the space (volume) in a specific time period.
* Students will use previously learned concepts of volume or research them if necessary.
* Students will use previously learned concepts of surface area or research them if necessary.
* Students will work together with one or more peers exercising skills of listening, flexibility, and compromise to achieve their goal.

**Lesson standards:**

**NGSS:**

**HS-ETS1-1 Engineering Design**

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**HS-ETS1-2 Engineering Design**

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

**HS-ETS1-3 Engineering Design**

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

**CCSS:**

**Standards for Mathematical Practice**

-Make sense of problems and persevere in solving them.

-Reason abstractly and quantitatively.

-Construct viable arguments and critique the reasoning of others.

-Model with mathematics.

-Use appropriate tools strategically.

-Look for and make use of structure.

-Look for and express regularity in repeated reasoning.

**HSG.MG.A.1 Modeling with Geometry**

Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).\*

**HSG.MG.A.3 Modeling with Geometry**

Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).\*

**CTE:**

1.A.1 Use a wide range of idea creation techniques (such as brainstorming).

3.B.2 Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal.

10.A.2 Prioritize, plan, and manage work to achieve the intended result.

**Soft skills:**

Communication, Collaboration, Critical Thinking, Information and Technology Literacy, Problem Solving

**Locally and/or personally relevant for students:**

We live in a region and has been and still is expecting a large earthquake to rock and potentially cripple this area temporarily. It is very possible that the earthquake could occur while on campus and students and staff will have to find ways to communicate with each other and potentially care for each other.

**Connections to career and educational pathways:**

Multiple engineering pathways, emergency preparedness and response

**Materials:**

Each group needs:

* Maximize the space lab
* 1 sheets of 8.5”x11” paper
* Scissors
* Tape
* Ruler

The teacher needs:

* Tape or magnets
* Technology to play videos on youtube.
* Measuring tape(s).
* Storage Container - either on campus (preferred option) or a picture and measurements of one.

**Lesson preparation:**

Have the materials above ready to go for the number of groups you have assigned.

**Time required:**

This lesson is suitable for a block period or two shorter periods. (60-100 minutes)

● Maximize the space lab - pair up students randomly.

● Play either video or both:

* <https://www.youtube.com/watch?v=YXxPTAhMGLI> (When the earth shakes 3:00)
* <https://www.fema.gov/media-library/assets/videos/139260> (PSA: Disasters don’t plan ahead you can 0:30)
* Present the problem statement.
* Make a field trip outside to see storage container and take measurements.
* With any remaining time all the students to start brainstorming needs in the event of an earthquake while school is in session.

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

In this portion of the lesson, students are just beginning to understand the problem and exploring what needs there will be and how to even begin to meet those needs. The teacher will help facilitate the lab and brainstorming at the end of class.

**Understanding the Problem**

|  |  |
| --- | --- |
| Teacher | Student |
| Briefly introduce lab. Count off students to work in random pairs.  (Accommodations/Extensions: Students in Algebra I/Geometry will need 15-20 minutes to complete this. Students in high level mathematics classes will need more time because they will spend more time doing calculations to find the best option before making their container.) | Students read through directions, ask any clarifying questions. Students begin working through the engineering design process although they may not realize that is what they are doing.  (15-30 minutes) |
| Debrief with students. Facilitate a discussion about: What steps did you find yourself working through? What worked well? What did not? Who planned ahead? Who jumped right in and began making a container? Consider showing a diagram of the engineering design process. | Listening and sharing with their peers. Processing what steps they worked through to reach their end goal. Students may find the steps in the engineering design process they did well or others that maybe they should have done better.  (10-20 minutes) |
| Show one or both videos.  Video 1 is an advertisement showing employees in a meeting getting a notification about an earthquake on Thursday which they then complain does not work with their schedule.  Video 2 is from the great shake out. Encourages the viewer to think about how prepared or unprepared they are and steps to take to be prepared in the event of an earthquake.  You may want to take time to ask the students to think about what being prepared on a school campus looks like. | Students are shifting to a different mindset. Thinking about earthquake preparedness.  Du  (5 minutes) |
| Introducing the problem statement.  Take the students to the storage unit on campus or find pictures of one. The storage unit used for this unit was a 40’ high cube container. Depending on where the unit is on campus will determine how much of class time you will use.  Check in with your campus emergency prep team and see if they have an inventory of what is already available in the container. | Students asking clarifying questions about the problem statement. (5 minutes)  Students visit the container. Every student should have the opportunity to walk through the container, take in the size and what is available.  Anticipate more visits to the container as groups recall what is already available and how much space it is taking up.  (20-30 minutes) |
| Facilitating a brainstorming session. Think-Pair-Share. Provide guided questions if needed. Make sure to connect to the lab. What are the immediate needs after an earthquake? How do we maximize the space available to us in the storage unit? Take a picture of the board. when done so students can refer back to their ideas later in the unit as needed. What careers do you see being connected to this problem? | Students brainstorming thoughts. Have one student record thoughts on the board.  (Any remaining time) |

**Accommodations and/or Extensions**:

* If students have not worked with volume or surface area formulas then keep the activity to a rectangular prism using something light (puffed rice) as a way to measure volume. You may also want to use this lesson as an application lesson after having taught rectangular prism surface area and volume.
* If students have taken Geometry, do not restrict their design process to just rectangular prisms, allow them to be creative in choosing their 3D figure. Have them calculate the volume and surface area and include their calculations on the board with their “box”. If time allows, this may lead to a discussion of which is better? Is it better to use all the material or have less material? Does that mean wasted material or money saved for using less? Which shape is in fact more practical in terms of storage? Etc.

**References/Resources:**

Maximize the Space Lab

(Adapted from <https://www.teachengineering.org/activities/view/cub_scale_model_lesson01_activity1>)

Videos:

* <https://www.youtube.com/watch?v=YXxPTAhMGLI> (When the earth shakes 3:00)
* <https://www.fema.gov/media-library/assets/videos/139260> (PSA: Disasters don’t plan ahead you can 0:30)

**Lesson 2 - Finding the Epicenter and Magnitude of an Earthquake**

**Problem statement:**

It seems like every day there is a new global crisis in the news: wildfires in California, hurricanes in the Caribbean, earthquakes in Mexico, and the refugee crisis in Syria. One of many issues in these times is how to get relief to the affected area when the usual methods are not available. What if there was just one product that could be sent to any of these places to provide relief for people?

Your task is to design and fill the interior of a shipping container placed on this campus to serve the staff and students in the event of an earthquake. What will be the most important items in your container? How much will it cost? Once you determine your design, determine what other areas of the world could be helped with your container.

**Learning objectives:**

• Students will learn what p and s waves are in an earthquake. They will learn how to look as

seismogram and identify the time difference it takes for the s waves to arrive after the p waves.

• Students will use the s-p value to identify on a graph how far away the seismograph is from the

epicenter.

• Students will use the the distance to draw circles with the corresponding radius on a map to find the

approximate location of the epicenter of the earthquake.

• Students will use a richter scale and graph both the distance and amplitude of the s wave to find the

approximate magnitude of the earthquake.

**Lesson standards:**

CCSS:

Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.

4. Model with mathematics.

5. Use appropriate tools strategically.

6. Attend to precision.

**[HSF.IF.B.4-Interpreting Functions](http://www.corestandards.org/Math/Content/HSF/IF/B/4/)**

For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity*.

**[HSF.IF.B.5-Interpreting Functions](http://www.corestandards.org/Math/Content/HSF/IF/B/5/)**

Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.*\*

**CTE:**

10.A.2 Prioritize, plan, and manage work to achieve the intended result.

**Soft skills:**

Communication, Collaboration, Critical Thinking, Information and Technology Literacy, Problem Solving

**Locally and/or personally relevant for students:**

We live in a region and has been and still is expecting a large earthquake to rock and potentially cripple this area temporarily. It is very possible that the earthquake could occur while on campus and students and staff will have to find ways to communicate with each other and potentially care for each other. The hope is that this scenario of caring for others will pull in female students who maybe did not see a connection between STEM careers like engineering and science and look at careers options in a new light.

**Connections to career and educational pathways:**

Seismologist, geophysicist, environmental sciences

**Materials:**

• Epicenter and Magnitude worksheet

• Map worksheet

• Compasses for drawing circles on the maps

• Technology to play youtube video explaining p- and s-waves.

**Time required:**

This lesson is suitable for a 55 minutes.

* Discussion regarding students’ knowledge and understanding of earthquakes.
* Youtube video
* Epicenter-magnitude worksheet
* Discussion of findings.
* Further research if time allows.

**What is the instruction?**

In this lesson, students will be exploring how an earthquake is measured and how those measurements are used to find the epicenter and magnitude.

**Understanding/Exploring the Problem**

|  |  |
| --- | --- |
| Teacher | Student |
| Facilitate a discussion on what the students know about earthquakes and how they are measured. See what vocabulary they know, for example, seismographs, seismograms, epicenter, magnitude, Richter scale, etc. Try and relate it to your region if possible. (Opportunity for a guest speaker in the field here.) | Students share their knowledge of earthquakes.  (10 minutes) |
| Show the youtube video describing p- and s-waves. Video is just under 5 minutes. <https://www.youtube.com/watch?v=HwY1ICqWGEA> | Students watch, take notes on any clarification they need.  (5-7 minutes) |
| Pass out the Epicenter and Magnitude investigation, the map, and compasses. (We found images of seismograms on google and provided axes that allowed us to create the epicenter and magnitude of our choosing.) Adjust to your region if possible. Monitor student work and answer clarifying questions. | Students should work individually but check in with their neighbor to make sure they are on track.  (15-20 minutes) |
| Facilitate a discussion around the students’ findings. Do they agree, disagree? What might lead to disagreement? | Students share their outcomes.  (5-10 minutes) |
| With remaining time or as an assignment you might allow students to research regional fault lines and predicted earthquakes. The Seattle and Whidbey Island fault lines are shallow faults that will result in a possible 6-7 magnitude earthquake. Since the fault is shallow, shaking will be severe. | Students can research using their phones or available technology in the school regarding regional earthquake predictions.  (Remaining time) |

**Accommodations and/or Extensions:**

* For students who engage better with technology have them use the website below and work through one of the 4 scenarios. It unfortunately does not have a scenario for the pacific northwest region for which this lesson has been adapted.

**References/Resources:**

Lesson adapted from Geology Labs Online <http://www.sciencecourseware.org/VirtualEarthquake/VQuakeExecute.html>

**Lesson 3 - Statement of Work & Proposals**

**Problem statement:**

The government is looking for companies to design the disaster pod for your school. They have certain criteria and requirements that must be met. But how do you determine which of the requirements are most important? In this lesson, you will learn how to use a decision matrix to make informed decisions when deciding what will go into your disaster pod proposal.

**Learning objectives:**

• Students will learn how to interpret a Statement of Work based on the Maximize the Space activity

performed in Lesson 1.

• Students will use a decision matrix to determine which of three proposals best meets the

requirements of the Statement of Work.

**Lesson standards:**

NGSS:

HS-ETS1-1 Engineering Design

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2 Engineering Design

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3 Engineering Design

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

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Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
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**Soft skills:**

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**Locally and/or personally relevant for students:**

We live in a region and has been and still is expecting a large earthquake to rock and potentially cripple this area temporarily. It is very possible that the earthquake could occur while on campus and students and staff will have to find ways to communicate with each other and potentially care for each other. The hope is that this scenario of caring for others will pull in female students who maybe did not see a connection between STEM careers like engineering and science and look at careers options in a new light.

**Connections to career and educational pathways:**

Multiple engineering pathways.

Consider a time in this unit in which you can either invite someone into the classroom or skype with someone outside of the classroom regarding careers in seismology, disaster preparedness, engineering, etc. Check in with the local universities and their department of environmental and occupational health sciences and/or see you there are any seismic labs located nearby.

**Materials:**

• Print out Pugh Chart Practice, Maximize the Space Statement of Work with Proposals on the back,

Disaster Relief Pod Statement of Work , and exit slip.

**Lesson preparation:**

Have the materials above ready to go for the number of groups you have assigned.

**Time required:**

This lesson is suitable for a 50-60-minute class period

* Introduce the concept of a decision matrix and why it might be needed. Have them work through the Pugh Chart Practice in pairs regarding Yuri choosing a car.
* Introduce the concept of a Statement of Work by going through the Maximize the Space Statement of Work with the class.
* Have each group use a decision matrix to determine which of the proposals best meets the requirements in the Statement of Work.
* Discuss results with the class and ask them why they chose a specific proposal.
* Distribute the Disaster Relief Pod Statement of Work and discuss any clarifying questions as a class.
* Use remaining time to brainstorm ideas for disaster pod.
* Have each student fill out the questionnaire about their career interests. These will be used to assign appropriate roles to the students for the remainder of the unit. If there is time in class they can fill it out then or send it home with them as an assignment.

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

In this lesson, students will be introduced to the real world concepts of requirements and proposals. The Teacher should go through and explain the Statement of Work and how to use a decision matrix to make informed, thoughtful, and objective decisions.

**Understanding/Exploring the Problem**

|  |  |
| --- | --- |
| Teacher | Student |
| Introduce a Pugh Chart/Decision Matrix. “This tool is also known as a criteria-based matrix. The Pugh matrix is a tool used to facilitate a disciplined, team-based process for concept generation and selection. Several concepts are evaluated according to their strengths and weaknesses against a base concept.” Pass out the practice worksheet. Have students work in pairs. | Students work in pairs to decide which car is better. Give students the opportunity to interpret what criteria is better and defend their thinking. |
| Have pairs turn to face another pair to compare their choice. Walk around to listen to statements that you can pull out and highlight with the entire class. | Groups of four discuss their choices and why. This will give another opportunity for individuals or pairs to defend their choice. |
| Facilitate discussion with the class to debrief the activity. What car did they choose? Did any pairs use a multiplier? Did they give weight to the same criteria, if they had not used a multiplier would the result have been the same? | Students offer up their choice and explain why.  ( Total 15-20 minutes) |
| Randomly change the student pairings. Pass out the Maximize the Space Statement of Work. Have them read through it and answer any clarifying questions. Then have them flip over the paper to review the 4 proposals. You may need to explain that they need to pick one proposal to be the one to compare all the others to. Accommodation: Choose one of the proposals to be the baseline. | Students work in pairs to determine which proposal is “best”. |
| Facilitate a discussion on how this was different from the car activity. For example they had to set one proposal as the baseline to compare all the others too. It was not clear what the most desired criteria is thus what kind of multipliers were used, did they consider things like all of the material used or wasted material? Did they make sacrifices and compromises? | Students share their results and explain their reasoning.  Students will struggle with wanting to know the right answer.  (20-25 minutes) |
| Pass out the statement of work for the disaster pod. Provide an opportunity for the students to read it completely. Answer any questions. Attempt to keep the idea broad right now so as not to narrow their focus this early in the process. | Students read the statement of work and then start to process with their peers to construct clarifying questions.  (10-20 minutes) |
| Make the connection to the statement of work.  Discussion: What are the criteria that your emergency storage container will be judged against?  Things should still be broadstroke at this point. But students should start thinking about competing with other bids and how they will come out on top. | Students brainstorming what would be in the left-hand column a decision matrix.  (Any remaining time) |
| Pass out the exit slip. In a quiet setting let the students answer the questions as best they can. Use these to create your four focus groups: communication/management, food/water, medical, shelter. | Students fill out their responses to the questions on the exit slip in class or at home as an assignment. |
| Outside of class time, read through the student responses and group them according to their interests. The four focus groups are communication/management, food/water, medical response, and shelter. |  |

**Accommodations and/or Extensions:**

* If students grasp the idea of the Statement of Work quickly, have them work together as a class to write their own version of a SoW for the disaster pod design.
* You may fill out the first column of the Pugh Chart Practice with + and - as an example to get students rolling on the task.
* The proposals can be modified to have more/less information to make the decision-making process more complicated or easier if necessary. You may also choose one proposal to be the base that all the other proposals are compared too. You may also choose less criteria or less proposals for the ease of translating any materials for ELL students.
* For an additional level of complexity, revise the statement of work to request that the pod be delivered and dropped from the air. This will put more emphasis on the packaging and placement aspects of the project.
* You may also consider having the student choose one aspect of their design to give a more detailed analysis of how the items will fit. For example, if they want to put all the first aid items in a bin, have them draw out in detail how each single item will fit and be arranged in the bin.

**References/Resources:**

How to Write a SoW for any Industry: <https://www.smartsheet.com/how-write-statement-work-any-industry>

“The Systems Engineering Tool Box” by Dr Stuart Burge <https://www.burgehugheswalsh.co.uk/uploaded/1/documents/pugh-matrix-v1.1.pdf>

Pugh Chart Practice: Washington Alliance for Better Schools by Shereen Henry

**Lesson 4 - Brainstorming**

**(This is will be the first opportunity for students to work in their newly assigned groups.)**

**Problem statement:**

It seems like every day there is a new global crisis in the news: wildfires in California, hurricanes in the Caribbean, earthquakes in Mexico, and the refugee crisis in Syria. One of many issues in these times is how to get relief to the affected area when the usual methods are not available. What if there was just one product that could be sent to any of these places to provide relief for people?

Your task is to design and fill the interior of a shipping container placed on this campus to serve the staff and students in the event of an earthquake. What will be the most important items in your container? How much will it cost? Once you determine your design, determine what other areas of the world could be helped with your container.

**Learning objectives:**

* Students will begin exploring their focus area (shelter, food and water, communication, medical response) by applying new brainstorming techniques.
* Students will analyze the employability rubric and discuss what the outlined expectations look like when in action.
* Students will work collaboratively create a plan for their next steps.

**Lesson standards:**

**NGSS:**

**HS-ETS1-1 Engineering Design**

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**HS-ETS1-2 Engineering Design**

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

**HS-ETS1-3 Engineering Design**

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

**CCSS:**

**Standards for Mathematical Practice**

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics
5. Use appropriate tools strategically.

**CTE:**

1.A.1 Use a wide range of idea creation techniques (such as brainstorming).

3.B.2 Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal.

10.A.2 Prioritize, plan, and manage work to achieve the intended result.

**Soft skills:**

Communication, Collaboration, Critical Thinking, Information and Technology Literacy, Problem Solving

**Locally and/or personally relevant for students:**

We live in a region and has been and still is expecting a large earthquake to rock and potentially cripple this area temporarily. It is very possible that the earthquake could occur while on campus and students and staff will have to find ways to communicate with each other and potentially care for each other. The hope is that this scenario of caring for others will pull in female students who maybe did not see a connection between STEM careers like engineering and science and look at careers options in a new light.

**Connections to career and educational pathways:**

Multiple engineering pathways, medical field, management

**Materials:**

-Brainstorming Presentation

-Employability Rubric - one for each student to keep as a reference

-Peer review half sheet - one for each group

**Lesson preparation:**

-Have the materials above ready to go for the number of groups you have assigned.

-Based on the exit slip, arrange class by their new groups.

**Time required:** 110 minutes\*

This lesson is suitable for a 55-minute class period.

\*Extra time is to be used so students get some in class time with their groups to brainstorm, research, and design the disaster pod. You may want to increase or decrease this time dependent on the type of students you have and the progress they are making on their design as the unit moves forward.

● Group students based on their responses to the exit slip at the end of lesson two. This should have already been done ahead of class time. (5 minutes)

* Pass out the employability rubric, have students discuss in their group what these expectations would look like. (10 minutes)
* Pass out the half sheet - assign a different student in each group to assess their group members. You may decide to do this daily or every other day as you see fit. (3 minutes)
* Present the problem statement and have students get out the statement of work from lesson 2.
* Go through the various techniques (brainstorming techniques presentation) that students could use to brainstorm ideas/solutions to the problem statement. (10 minutes)
* Allow any remaining time to allow students to brainstorm in their groups.

Note about grouping: Based on a class size of 28-36 students, the class should be split into two teams (businesses). Those two teams are broken up into four groups: water/food/nutrition, communication/management, medical response, shelter. These two teams (more if you have multiple sections of the class) are then competing against each other to win the contract. Consider having the administration team come in on the day of presentations to decide which group wins the bid for the school.

**What is the instruction?**

In this portion of the lesson, students are just beginning to explore what needs there will be in the event of an earthquake. The teacher will share brainstorming techniques and facilitate actual brainstorming during class time.

**Exploring the Problem**

|  |  |
| --- | --- |
| Teacher | Student |
| Group the students based on their responses to the exit slip from lesson 2. Pass out the employability rubric and the peer review half sheet to all students. Have the look over it and facilitate a discussion on what these expectations look like in action in the classroom. | Discussing as a class or group what these expectations actually look like. |
| Present the various brainstorming techniques. | Students taking notes as needed. |
| Share with the new groups what their focus area is based on the exit slips from lesson 2. Have them pick a lead for their group. This is someone who will meet with the other three leads in the other focus areas. They should consider who will be objective yet fight for what the group wants in the disaster pod. | Students determine who will represent their focus group with the whole group. |
| Facilitate time for the groups to apply the techniques and brainstorm thoughts, ideas, and solutions regarding their specific focus. Teacher can encourage silent time for individual brainstorming first or let the groups dive in and build off of each others ideas. Make sure that each group has someone recording their thoughts.  (See accommodations/extensions.) | Students are brainstorming individually and/or as a group. Someone in each group is recording the groups ideas. |

**Accommodations and/or Extensions**:

Depending on the motivation/engagement of your students you many either let the students go ahead and run themselves during the brainstorming process or you may want to pick 2 or three techniques and have them use them for a set amount of time.

**References/Resources:**

Exit Slip from Lesson 2 <https://www.forbes.com/sites/dailymuse/2013/11/01/9-questions-thatll-help-you-find-your-dream-career/#785dc76253d9>

Brainstorming Techniques

<https://www.inc.com/john-boitnott/10-longtime-brainstorming-techniques-that-still-work.html>

**Lesson 5 - Packaging Lab**

**How will items put into the storage container survive an earthquake?**

**Problem statement:**

It seems like every day there is a new global crisis in the news: wildfires in California, hurricanes in the Caribbean, earthquakes in Mexico, and the refugee crisis in Syria. One of many issues in these times is how to get relief to the affected area when the usual methods are not available. What if there was just one product that could be sent to any of these places to provide relief for people?

Your task is to design and fill the interior of a shipping container placed on this campus to serve the staff and students in the event of an earthquake. What will be the most important items in your container? How much will it cost? Once you determine your design, determine what other areas of the world could be helped with your container.

**Learning objectives:**

* Students will collaborate with their peers to package a pringle chip for survivability in the mail.
* Students will work within specific parameters for their packaging.
* Students will work collaboratively to design, test, and redesign their package.
* Students will apply the concept of packaging to the work they are doing for the disaster pod.

**Lesson standards:**

**NGSS:**

**HS-ETS1-1 Engineering Design**

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**HS-ETS1-2 Engineering Design**

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

**HS-ETS1-3 Engineering Design**

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

**CCSS:**

**Standards for Mathematical Practice**

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.

**CTE:**

1.A.1 Use a wide range of idea creation techniques (such as brainstorming).

3.B.2 Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal.

10.A.2 Prioritize, plan, and manage work to achieve the intended result.

**Soft skills:**

Communication, Collaboration, Critical Thinking, Information and Technology Literacy, Problem Solving

**Locally and/or personally relevant for students:**

We live in a region and has been and still is expecting a large earthquake to rock and potentially cripple this area temporarily. It is very possible that the earthquake could occur while on campus and students and staff will have to find ways to communicate with each other and potentially care for each other. The hope is that this scenario of caring for others will pull in female students who maybe did not see a connection between STEM careers like engineering and science and look at careers options in a new light.

**Connections to career and educational pathways:**

Multiple engineering pathways, medical field, management

**Materials:**

-Packaging Lab materials - provided on the instruction sheet

-Packaging Lab student instruction sheet with shopping list

-Packaging Lab shopping list

-Packaging Lab Evaluation sheet

-Container large enough to hold water and submerge student package.

**Lesson preparation:**

Have a table with the materials ready to go so that students may get their shopping done in one place that is easy to supervise.

**Time required:** 110 minutes\*

This lesson is suitable for a 55-65 minute class period.

\*Extra time is to be used so students get some in class time with their groups to brainstorm, research, and design the disaster pod. You may want to increase or decrease this time dependent on the type of students you have and the progress they are making on their design as the unit moves forward.

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

In this portion of the lesson, students are just beginning to understand and explore what needs there will be in the event of an earthquake. The students have spent time brainstorming the specific needs based on their groupings but now they have to consider how those items and solutions they have been researching will survive the earthquake.

**Exploring the Problem**

|  |  |
| --- | --- |
| Teacher | Student |
| Introduce the lab - pass out the instruction sheet. | Students begin brainstorming and designing a package. (10-15 minutes) |
| Supervising material shopping. | Students present their design in order to buy materials. (5-10 minutes) |
| Supervising package building. | Students are taking this time to build and test their package. They are then reevaluating and making changes with their 3 test chips. (15-20 minutes) |
| Final Evaluations. Based on their tests all the students to go out of order to keep their chip intact as long as possible. | As groups are ready, they must apply the survivability tests with the teacher present to verify that they pass the test. (10-20 minutes) |
| Make the connection to the PBL. Ask the class how the items they have been researching and designing will survive the earthquake? | Students begin discussing and brainstorming in their focus group about the items they are choosing to put into the disaster pod and how to make sure they survive. (Remaining time) |

**Accommodations and/or Extensions**:

Extension - Have the students mail their packages from home to school. Award points for how well the pringle survived.

Accommodations - You can restrict the materials to keep things simple but yet still allow for creativity within their design.

**References/Resources:**

Lab adapted from

<https://www.teachengineering.org/activities/view/design_packing_that_works>

**Lesson 6 - Sustainability**

**Problem statement:**

It seems like every day there is a new global crisis in the news: wildfires in California, hurricanes in the Caribbean, earthquakes in Mexico, and the refugee crisis in Syria. One of many issues in these times is how to get relief to the affected area when the usual methods are not available. What if there was just one product that could be sent to any of these places to provide relief for people?

Your task is to design and fill the interior of a shipping container placed on this campus to serve the staff and students in the event of an earthquake. What will be the most important items in your container? How much will it cost? Once you determine your design, determine what other areas of the world could be helped with your container.

**Learning objectives:**

* Students will collaborate with their peers to reevaluate the contents of their storage container based on the needs of a different global crisis.
* Students will work collaborate with their peers to reevaluate how to package and organize the contents of their storage container based on the needs of a different global crisis.

**Lesson standards:**

**NGSS:**

**HS-ETS1-1 Engineering Design**

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**HS-ETS1-2 Engineering Design**

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

**HS-ETS1-3 Engineering Design**

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

**CCSS:**

**Standards for Mathematical Practice**

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.

**CTE:**

3.B.2 Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal.

10.A.2 Prioritize, plan, and manage work to achieve the intended result.

**Soft skills:**

Communication, Collaboration, Critical Thinking, Information and Technology Literacy, Problem Solving

**Locally and/or personally relevant for students:**

We live in a region and has been and still is expecting a large earthquake to rock and potentially cripple this area temporarily. It is very possible that the earthquake could occur while on campus and students and staff will have to find ways to communicate with each other and potentially care for each other. The hope is that this scenario of caring for others will pull in female students who maybe did not see a connection between STEM careers like engineering and science and look at careers options in a new light.

**Connections to career and educational pathways:**

Multiple engineering pathways, medical field, management

**Materials:**

- Access to technology for research.

**Lesson preparation:**

Have slips of paper that the group leaders will draw from a hat. The number of slips of paper depend on the number of groups you have participating. The slips of paper should have other possible global crisis on them. Examples include but are not limit to: hurricanes, flooding, fires, mudslides, tornadoes, power grid failure, water supply failure, refugee crisis, etc.

**Time required:**

This is really a research opportunity for the students. Students may be given in class time or be required to complete the work outside of class. Provide sometime in class, 45 minutes, to allow time for students to discuss the changes needed for their emergency container and collaborate to make those changes happen.

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

In this portion of the unit, the students are working to resolve the problem.

**Resolving the Problem**

|  |  |
| --- | --- |
| Teacher | Student |
| Have each group draw a slip of paper from a hat. | Students consider the needs in the new crisis they have been given. Students research the needs in that crisis and how they may differ from the earthquake scenario. |
| Be available to answer any clarifying questions. Encourage students to think about that they can keep, what they need to add, and does it need to be packaged differently. | Students consider how their contents should be organized and packaged based on the new crisis. |
| Encourage students to consider how much more marketable their product will be if it addresses more than one global crisis. | Students should be making changes as needed to the technology part of their presentation and to the proposal. |

**Accommodations and/or Extensions**:

An extension for the students to consider that will also cause the students to reflect back to the packaging lab is to consider the possibility that their container will be picked up and dropped off by helicopter. How would the contents of their container survive?

**Lesson 7 - Student Disaster Pod Presentations**

**Problem statement:**

It seems like every day there is a new global crisis in the news: wildfires in California, hurricanes in the Caribbean, earthquakes in Mexico, and the refugee crisis in Syria. One of many issues in these times is how to get relief to the affected area when the usual methods are not available. What if there was just one product that could be sent to any of these places to provide relief for people?

Your task is to design and fill the interior of a shipping container placed on this campus to serve the staff and students in the event of an earthquake. What will be the most important items in your container? How much will it cost? Once you determine your design, determine what other areas of the world could be helped with your container.

**Learning objectives:**

* Students will collaborate with their peers to create a presentation with a technological component.
* Students will work collaborate with their peers to finalize an overall proposal with a budget, diagram, explanation of compromises and splurge, having been given both the decision matrix and project rubric.
* Students will engage in public speaking to present their proposals to their peers and invited faculty members.
* Students will construct questions for their peers that reflect thoughtful, intelligent understanding of the project.

**Lesson standards:**

**NGSS:**

**HS-ETS1-1 Engineering Design**

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**HS-ETS1-2 Engineering Design**

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

**HS-ETS1-3 Engineering Design**

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

**CCSS:**

**Standards for Mathematical Practice**

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.

**CTE:**

3.B.2 Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal.

10.A.2 Prioritize, plan, and manage work to achieve the intended result.

**Soft skills:**

Communication, Collaboration, Critical Thinking, Information and Technology Literacy, Problem Solving

**Locally and/or personally relevant for students:**

We live in a region and has been and still is expecting a large earthquake to rock and potentially cripple this area temporarily. It is very possible that the earthquake could occur while on campus and students and staff will have to find ways to communicate with each other and potentially care for each other. The hope is that this scenario of caring for others will pull in female students who maybe did not see a connection between STEM careers like engineering and science and look at careers options in a new light.

**Connections to career and educational pathways:**

Multiple engineering pathways, medical field, management

**Materials:**

- Access to technology to present a google slideshow or powerpoint.

- Decision matrix for faculty invited

- Rubric

**Lesson preparation:**

Prior to this date invite faculty members to attend the presentations, these people could be administrators, campus supervisors, and/or staff members who are a part of the emergency preparation team if your school has one. Make sure that before students present the invited guests understand the Statement of work the students were given and how to fill out a decision matrix.

**Time required:**

Allow for each group to have up to 25 minutes total. Expect 5 minutes of transition, getting the technology ready and making sure that each guest has a paper copy of each proposal. Limit presentation time to 10-15 minutes. Depending on the number of groups presenting this will take 30-40 minutes.

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

In this portion of the unit, the students are presenting their solution to problem.

**Resolving the Problem**

|  |  |
| --- | --- |
| Teacher | Student |
|  | Students are preparing the slideshow and passing out their proposals to the invited faculty members. Have one or two students explain to the questions what the problem statement was and the statement of work.  Have another pair of students explain to the guests how to use the decision matrix. (5-10 minutes) |
| Taking notes and filling out the decision matrix. | 4-6 students from each group or business present their solution for the disaster pod. Given 14-16 students in each business, the groups picked experts from each focus group to be part of the presentation group. (10-15 minutes) |
| Asking questions, monitoring the questions and the time. | Students and invited questions are allowed time to ask questions. (5 minutes)  Repeat as needed for the number of groups. |
| Facilitate a discussion about the takeaways from this experience. | Students share what they enjoyed, learned, struggled with over the course of the unit.  (Remaining time) |

1. The sub-sections of the procedure section (e.g., Understand the Problem, Explore the Problem) are from the Illinois Math and Science Academy’s PBL Teaching and Learning Template, however, the descriptions were developed by WABS and do not necessarily represent the views of IMSA. [↑](#footnote-ref-0)