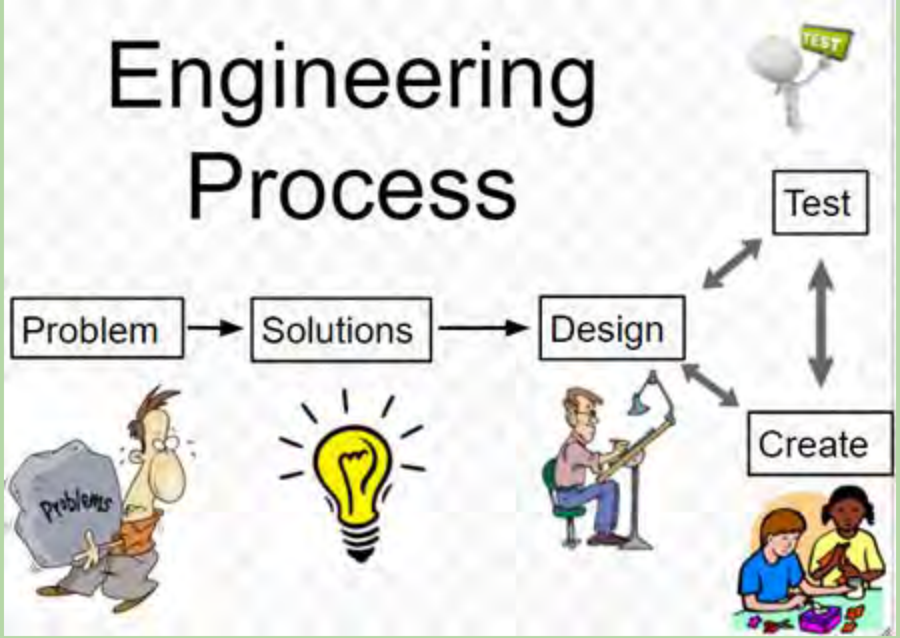
Title: K-8 NGSS Aligned Engineering Design Projects

Join us to see multiple K-8 engineering design projects that have been implemented over the last 3 years. These projects will provide you with ideas and context for us to discuss how to incorporate engineering design into your classroom. You will be supplied with classroom materials for the projects that are shared. Project Topics will include: Stormwater Runoff, Ocean Plastic Pollution, Air Pollution and Erosion Control Measures.

Performance Expectations That Incorporate Engineering Practices

	Physical Science	Life Science	Earth and Space Science	Engineering
K	K-PS3-2		K-ESS3-2 K-ESS3-3	K-2-ETS1-1 K-2-ETS1-2 K-2-ETS1-3
1	1-PS4-4	1-LS1-1		
2	2-PS1-3	2-LS2-2	2-ESS2-1	
3	3-PS2-4	3-LS4-4	3-ESS3-1	3-5-ETS1-1 3-5-ETS1-2 3-5-ETS1-3
4	4-PS3-4 4-PS4-3		4-ESS3-2	
5				
6-8	MS-PS1-6 MS-PS2-1 MS-PS3-3	MS-LS2-5		MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4
9-12	HS-PS1-6 HS-PS2-3 HS-PS2-3 HS-PS4-5 HS-PS2-6	HS-LS2-7 HS-LS4-6	HS-ESS1-2 HS-ESS3-2 HS-ESS2-2 HS-ESS3-4 HS-ESS3-4	HS-ETS1-1 HS-ETS1-2 HS-ETS1-3 HS-ETS1-4



Performance Expectations That Incorporate Engineering Practices

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2	2-PS1-3	2-LS2-2	2-ESS2-1	
3	3-PS2-4	3-LS4-4	3-ESS3-1	3-5-ETS1-1
4	4-PS3-4 4-PS4-3		4-ESS3-2	3-5-ETS1-2 3-5-ETS1-3
5				
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3-5-ETS1 Engineering Design

3-5-ETS1 Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*.

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.

- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

ETS1.B: Developing Possible Solutions

- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)

ETS1.C: Optimizing the Design Solution

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)

Crosscutting Concepts

Influence of Engineering, Technology, and Science on Society and the Natural World

- People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)
- Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

Connections to 3-5-ETS1.A: Defining and Delimiting Engineering Problems include:

MS-ETS1 Engineering Design

MS-ETS1 Engineering Design

Students who demonstrate understanding can:

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4)

Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)

Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

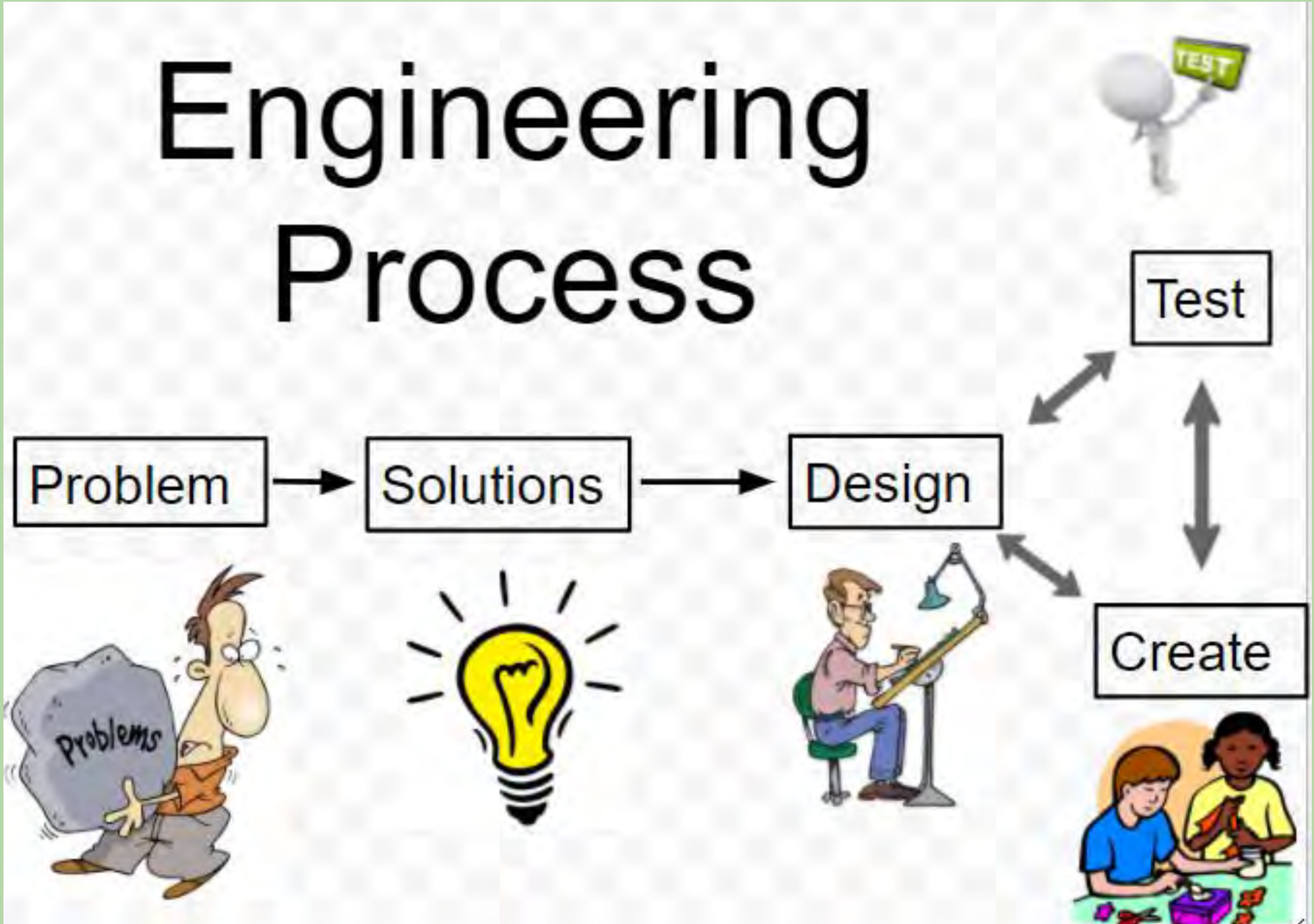
ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

Crosscutting Concepts

Influence of Science, Engineering, and Technology on Society and the Natural World

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1)
- The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)



Engineering Process
TEST
Test
Problem
Solutions
Design
Create
Problems

Plastic Bots

5th Grade and Middle School NGSS Aligned

*Thank you **Franklin Lakes** Middle School Teachers*

5-ESS3 Earth and Human Activity

5-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.

- Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. (5-ESS3-1)

Disciplinary Core Ideas

ESS3.C: Human Impacts on Earth Systems

- Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)

Crosscutting Concepts

Systems and System Models

- A system can be described in terms of its components and their interactions. (5-ESS3-1)

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World.

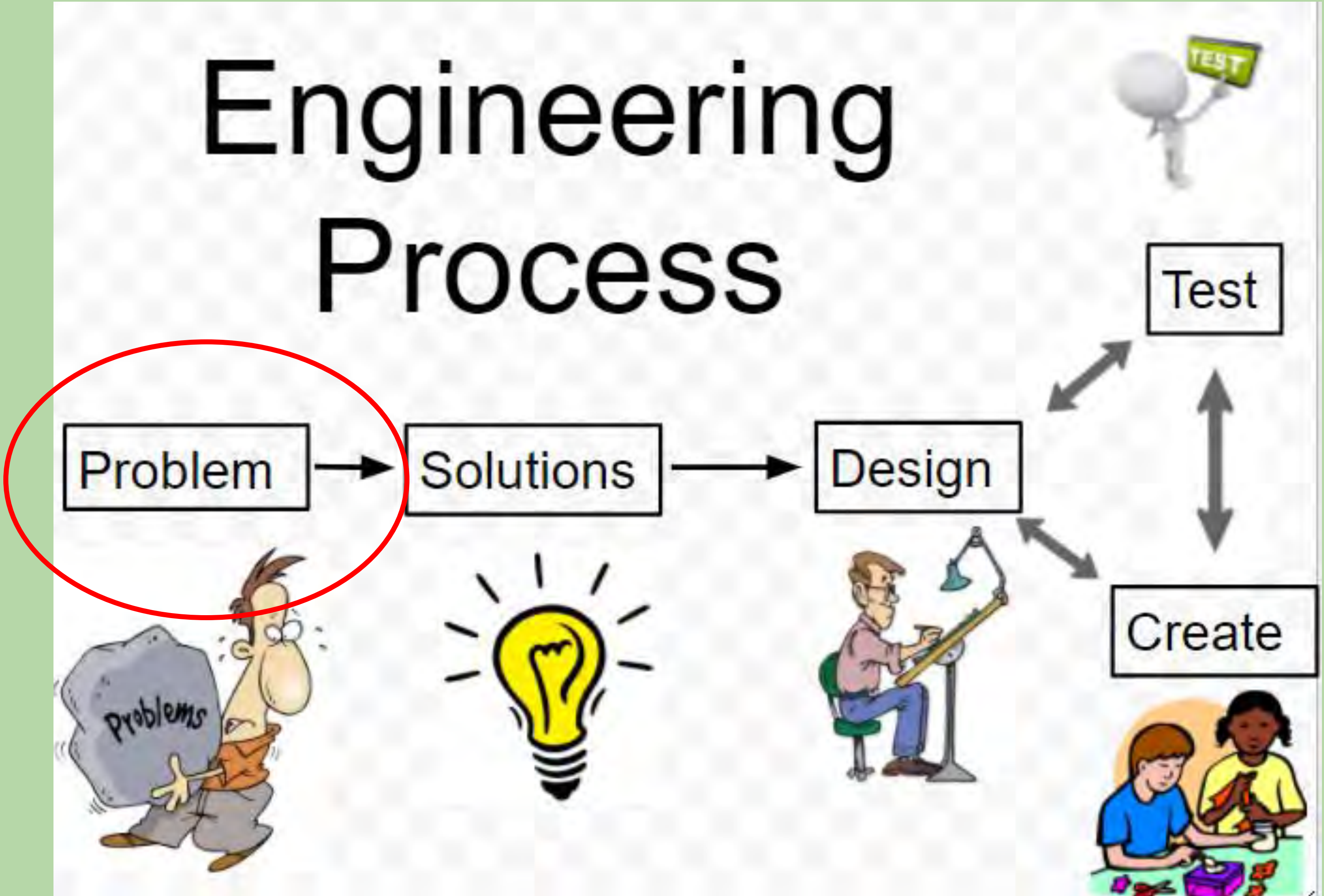
- Science findings are limited to questions that can be answered with empirical evidence. (5-ESS3-1)

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics	
Students who demonstrate understanding can:	
MS-LS2-1.	**Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]
MS-LS2-2.	**Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.** [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]
MS-LS2-3.	**Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.** [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]
MS-LS2-4.	**Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]
MS-LS2-5.	**Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*** [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

MS-ESS3 Earth and Human Activity

MS-ESS3	Earth and Human Activity
Students who demonstrate understanding can:	
MS-ESS3-1.	**Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.** [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]
MS-ESS3-2.	**Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.** [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]
MS-ESS3-3.	**Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*** [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]
MS-ESS3-4.	**Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.** [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]
MS-ESS3-5.	**Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.** [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

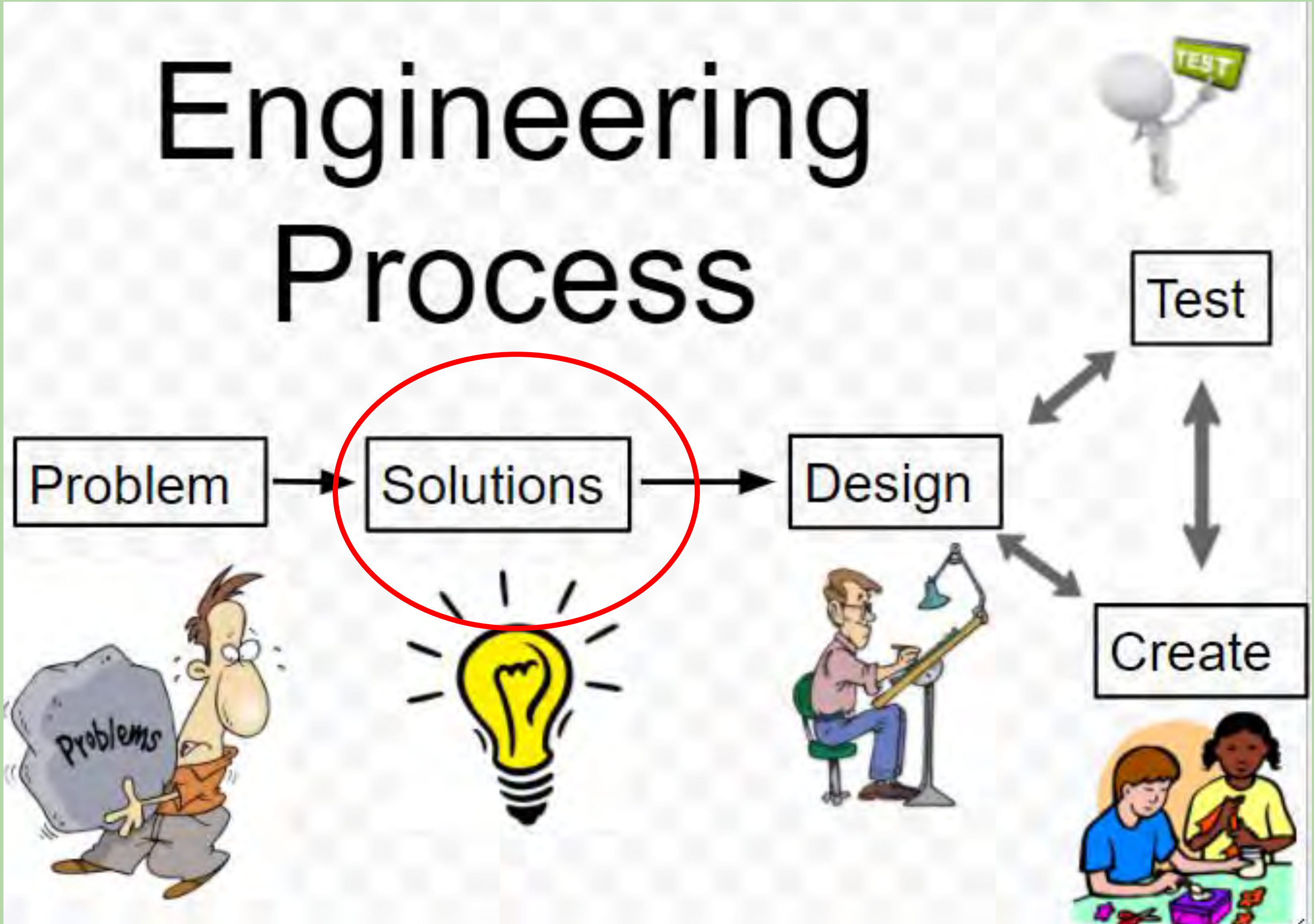

Engineering
Process
Problem
Solutions
Design
Test
Create
TEST
Problems

Record your Observations in this table

Observations


A
PLASTIC
OCEAN
WE NEED A WAVE OF CHANGE.

Problem	
Plastic heavily pollutes the world's oceans.	
Useful Questions	Causes


Engineering
Process
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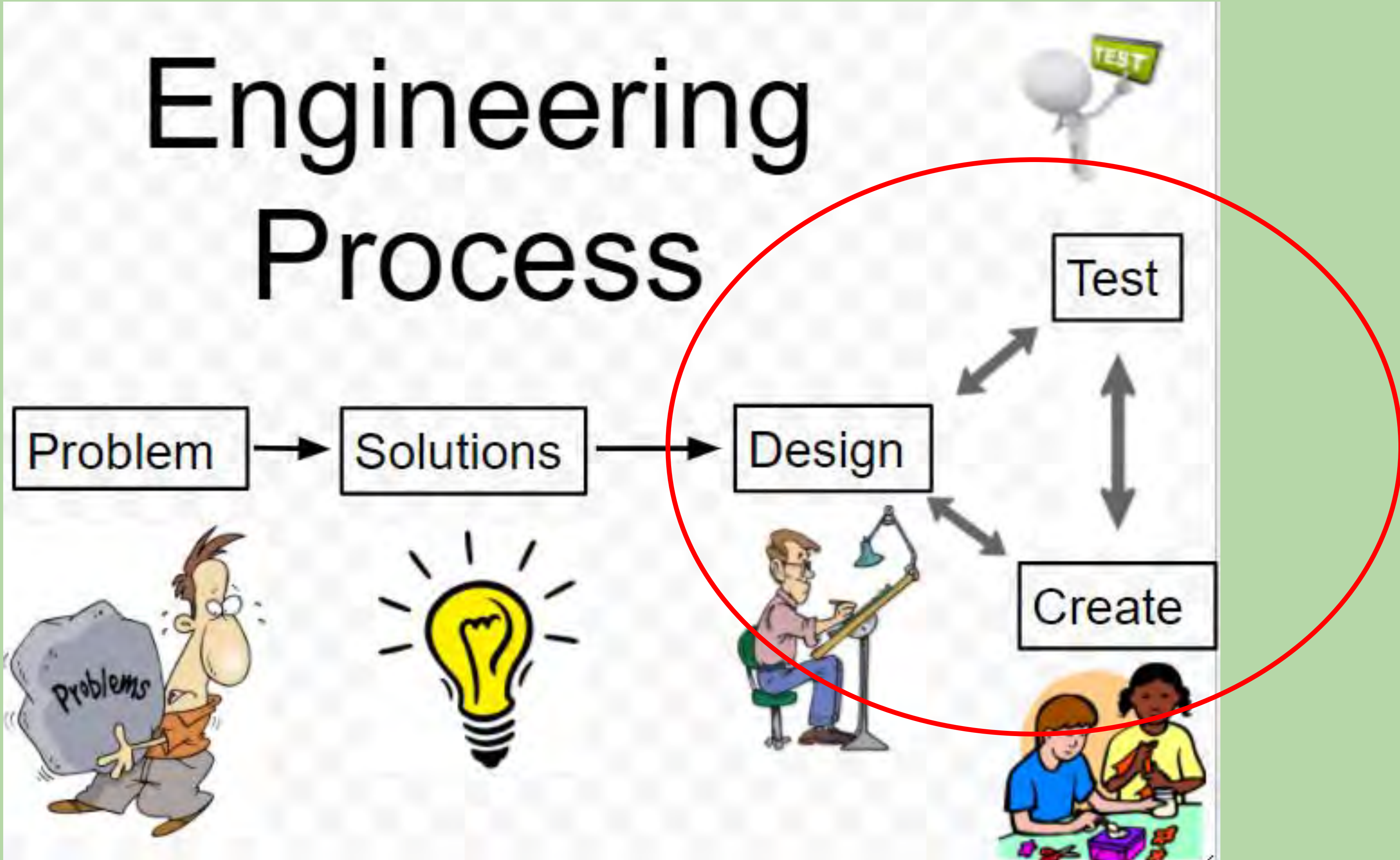
Plastic Bots Solutions

Strategy	Explain how this will solve the problem	Sketch
The Ocean Clean Up https://www.theoceancleanup.com/milestones/north-sea-prototype/ Floating Screens		
Bucket (first solution in article)		
Trash Eaters		
Other: Find another solution Source: ____________________		


Engineering Process
TEST
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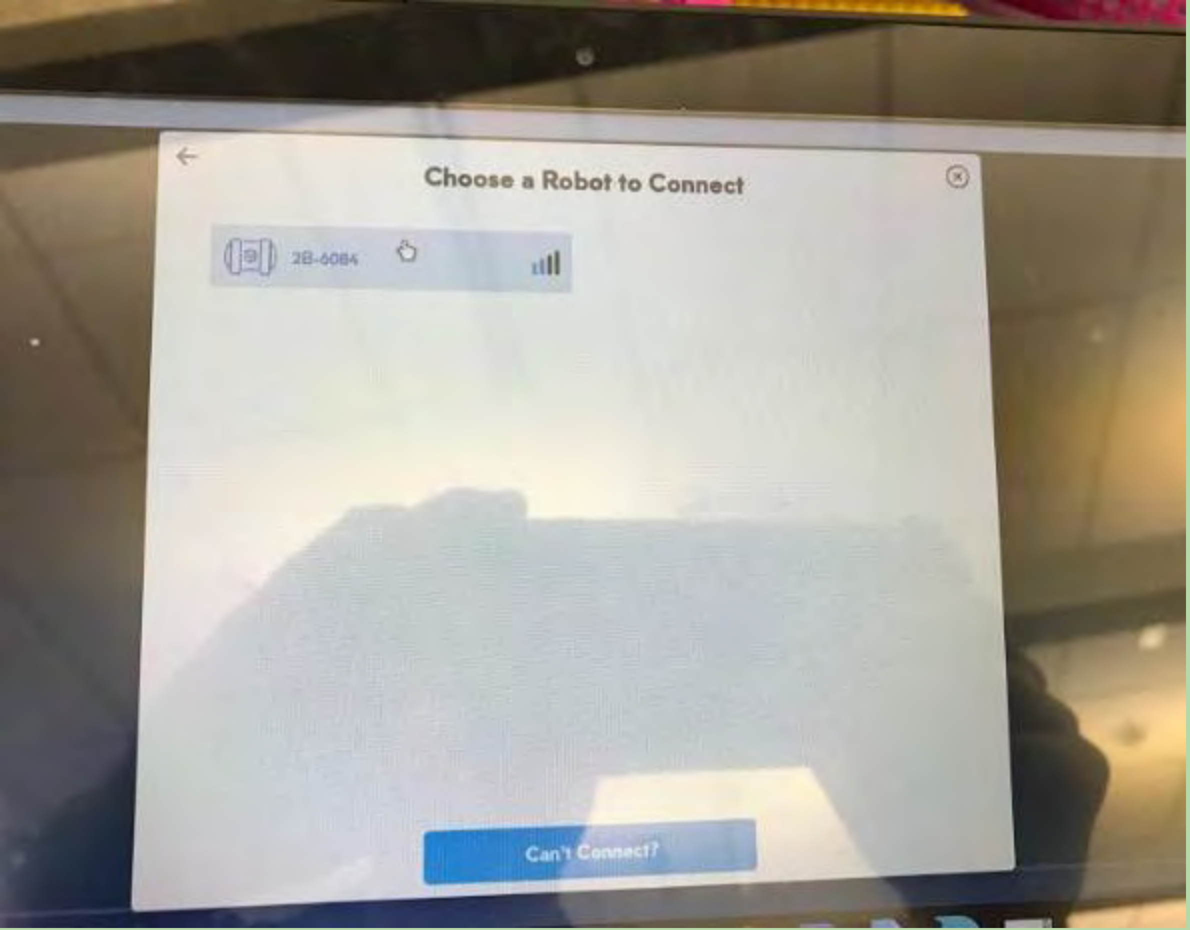
Save the Oceans Project

Design Brief:	The numbers are staggering: There are 5.25 trillion pieces of plastic debris in the ocean. Of that mass, 269,000 tons float on the surface, while some four billion plastic microfibers per square kilometer litter the deep sea.
Problem:	Plastic heavily pollutes the world's oceans
Solution:	Humans can create devices to collect the plastic debris
Task:	Design a shell that will fit onto the sphero that will collect plastic debris

Criteria/Constraints

1. The device must collect as much plastic as possible (pushing it to your goal)
2. Must be 9 cm in height **part of each side*
3. Must use the provided top
4. Must use approved materials
5. 75 gram mass limit (the shell not the mounting unit)


Choose a Robot to Connect
2B-6084
Can't Connect?


Diane
6084

Plastic Bots

Design Brief:	The numbers are staggering: There are 5.25 trillion pieces of plastic debris in the ocean. Of that mass, 269,000 tons float on the surface, while some four billion plastic microfibers per square kilometer litter the deep sea.
Problem:	Plastic heavily pollutes the world's oceans
Solution:	Humans can create devices to collect the plastic debris
Task:	Design a shell that will fit onto the sphero that will collect plastic debris from a model ocean

Initial Design: Draw an initial design of a solution to the problem.

Top View	Side View
	

Second Design

Design (top view)	Design (side view)

Useful Observations for improvement

- ____
- ____

How are you going to improve on this design? (2 changes)

- ____
- ____

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Plastic Bots Investigation

Target Question: Which Solution is most effective?

Directions: Use this table to organize your testing evidence.

Evidence

Bot Name	Useful Observations from Testing	Total Plastic Collected Mass	[illegible]	**Reasoning** - explain how you used the evidence to rank each solution

Statement Specific Rubric: : Generate Multiple Solutions

Generates and compare multiple solutions that solve a real world problem **evidence focus is on patterns and cause and effect relationships*		
1	**2**	**3**
Is unable to evaluate the merit a solution with evidence	Is able to evaluate the merit of one solution with one type of evidence to support their claim **Accuracy** **Claim:** Is accurate or logically connected to one type of evidence (observation) **logically connected means the claim makes sense based on the students thinking but may not be accurate* **can be applied to content mastery evaluation*	Is able to evaluate the merit of more than one solution using multiple types of evidence to support their claim **Accuracy** **Claim:** Is accurate and fully supported by their evidence **can be applied to content mastery evaluation*
Teacher Generated Example		

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Plastic Bots Investigation

Target Question: Which Solution is most effective?

Directions: Use this table to organize your testing evidence. **Evidence**

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Stormwater Runoff

4th Grade and Middle School NGSS Aligned

Stormwater Runoff Project

4-ESS3 Earth and Human Activity

4-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]

4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* [Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Stormwater Runoff Project

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

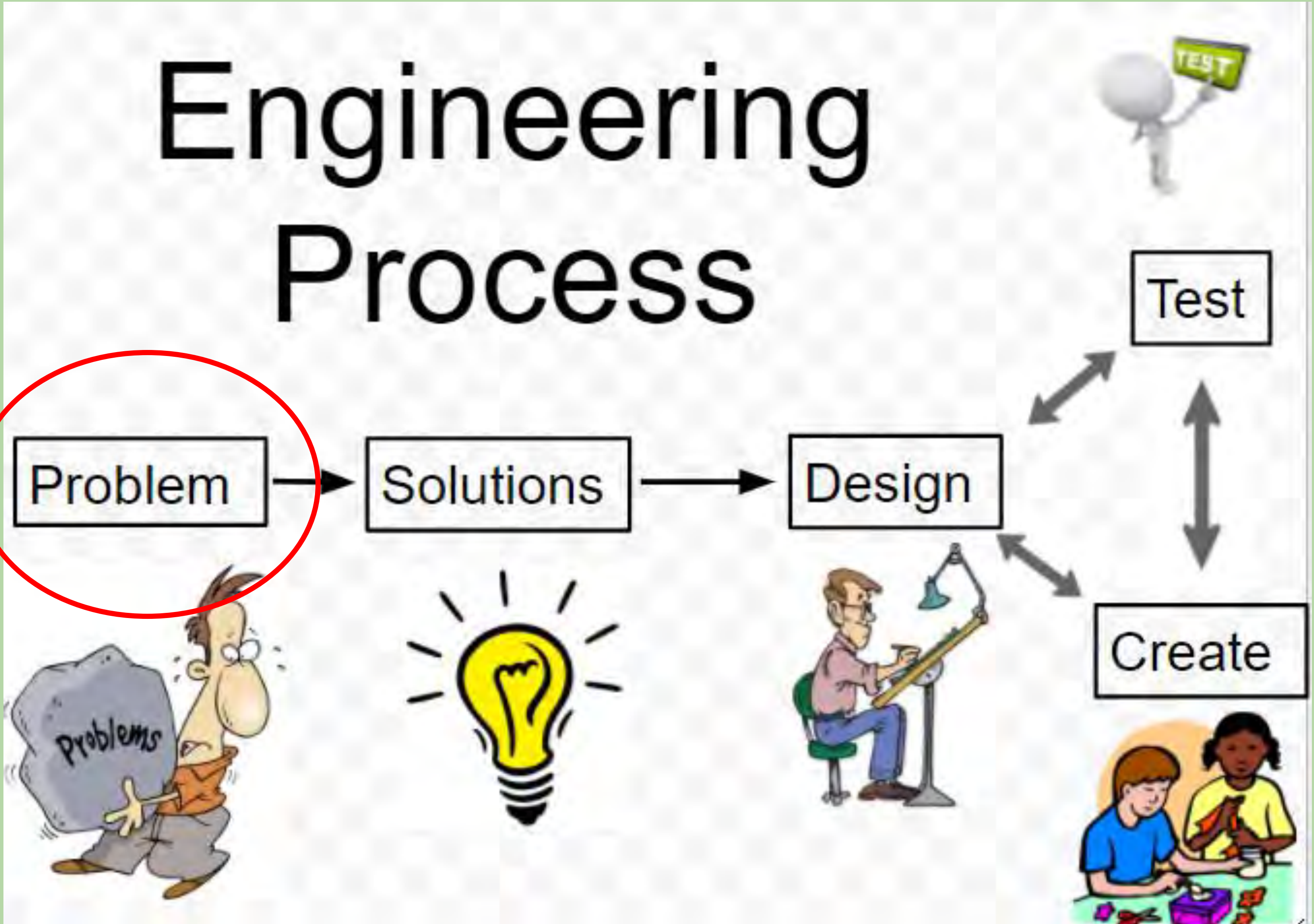
MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:


Engineering
Process
TEST
Test
Problem
Solutions
Design
Create
Problems

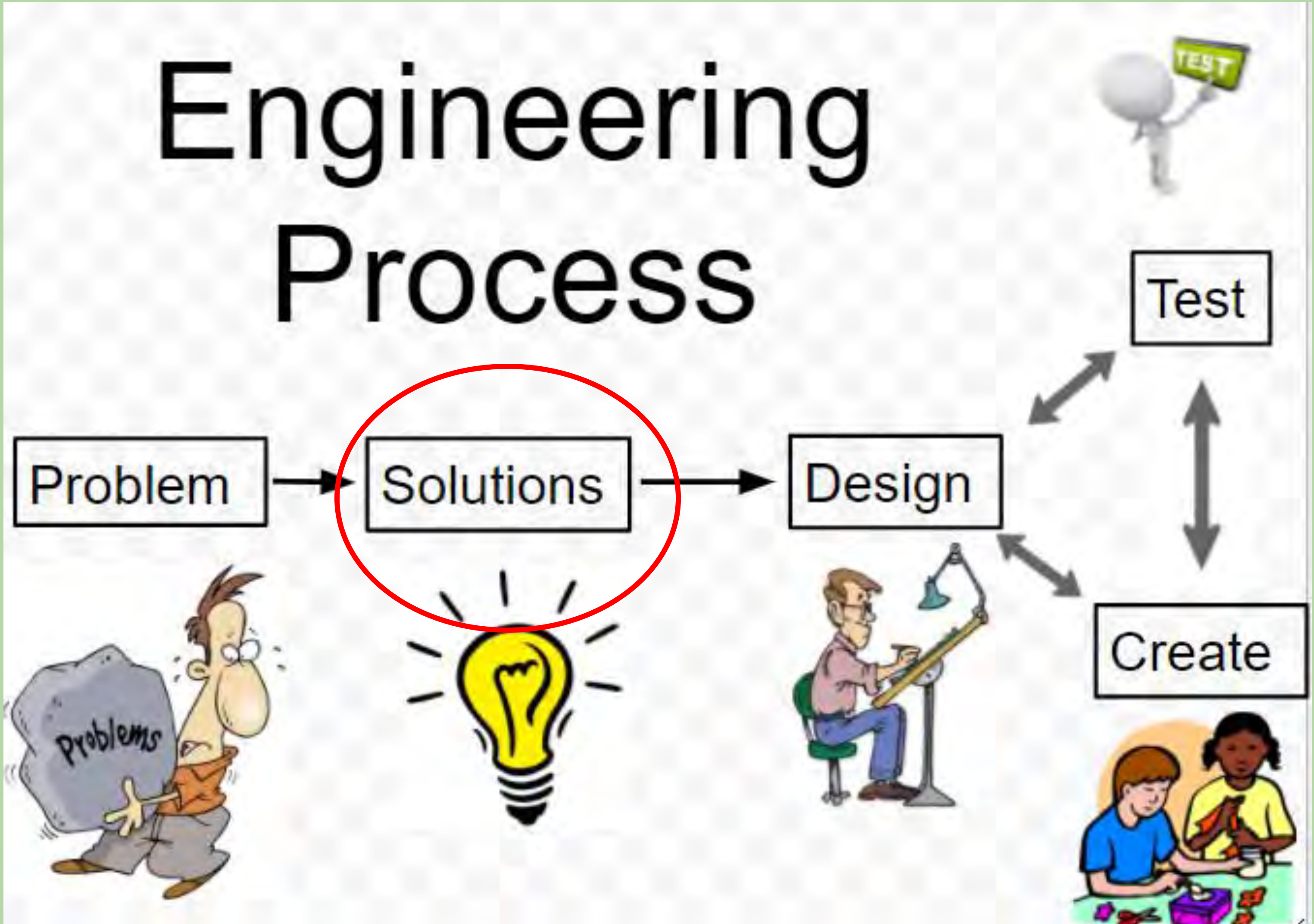

Stormwater Runoff
Runoff from Roof Surfaces
Roof/Gutter Downspouts
Yard Runoff
SCHOOL
STREET
Storm Drain Inlet
Gutter and Street Runoff
Storm Drain System
HWY
Storm Drain Inlet
Storm Drain System
Storm Drain Outlet
Water Body
Stormwater runoff ends up in local creeks, streams, lakes, rivers, and/or the ocean.

4th Grade

Problem	
Human engineered systems move water quickly to waterways which increases the risk of flooding.	
Useful Questions	Causes

Middle School

Problem	
Human engineered systems move water quickly to waterways which has a negative impact on local stream biodiversity.	
Useful Questions	Causes


Engineering Process
TEST
Test
Problem
Solutions
Design
Create
Problems

Name:____

Resources:

- https://www.wavin.com/en-en/News-Cases/News/10-measures-to-prevent-urban-flooding
- https://drive.google.com/open?id=0Bws_jlOmyrwlZXMxanFIUDVNdHZ3RWxuZEZkSTI3TDJOX0xN

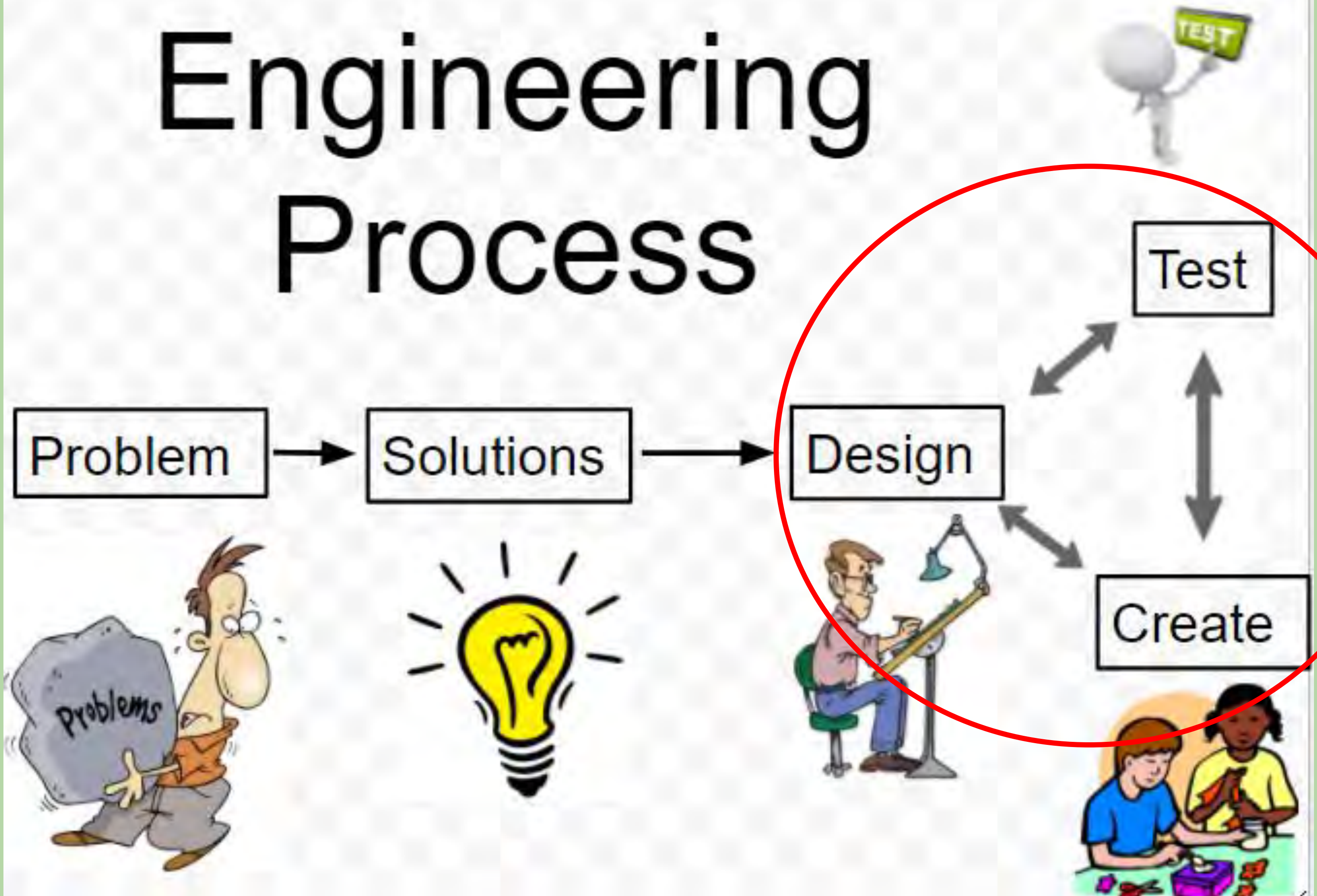
Green Infrastructure:____

____

Solution Research

Solution	Describe the Solution	How does the solution solve the problem?
Green Roof		
Rain Garden		
Bioswale		
Rain Barrel/Cistern		
Planters		

Engineering Process



Flooding Engineering Design Project

Design Brief:	Humans cannot eliminate flooding but can take steps to reduce the overall negative impact.
Engineering Problem:	Many Residential properties have Stormwater Runoff systems that move water off the property as quickly as possible into our local waterways which can increase the risk of flooding.
Solution:	Humans can install green infrastructure that will allow for more infiltration and slow the water down which will reduce the risk of flooding.
Task:	Redesign a residential property drainage system with green infrastructure to slow down water and allow for more infiltration which will reduce the negative impact of flooding

Residential Property.

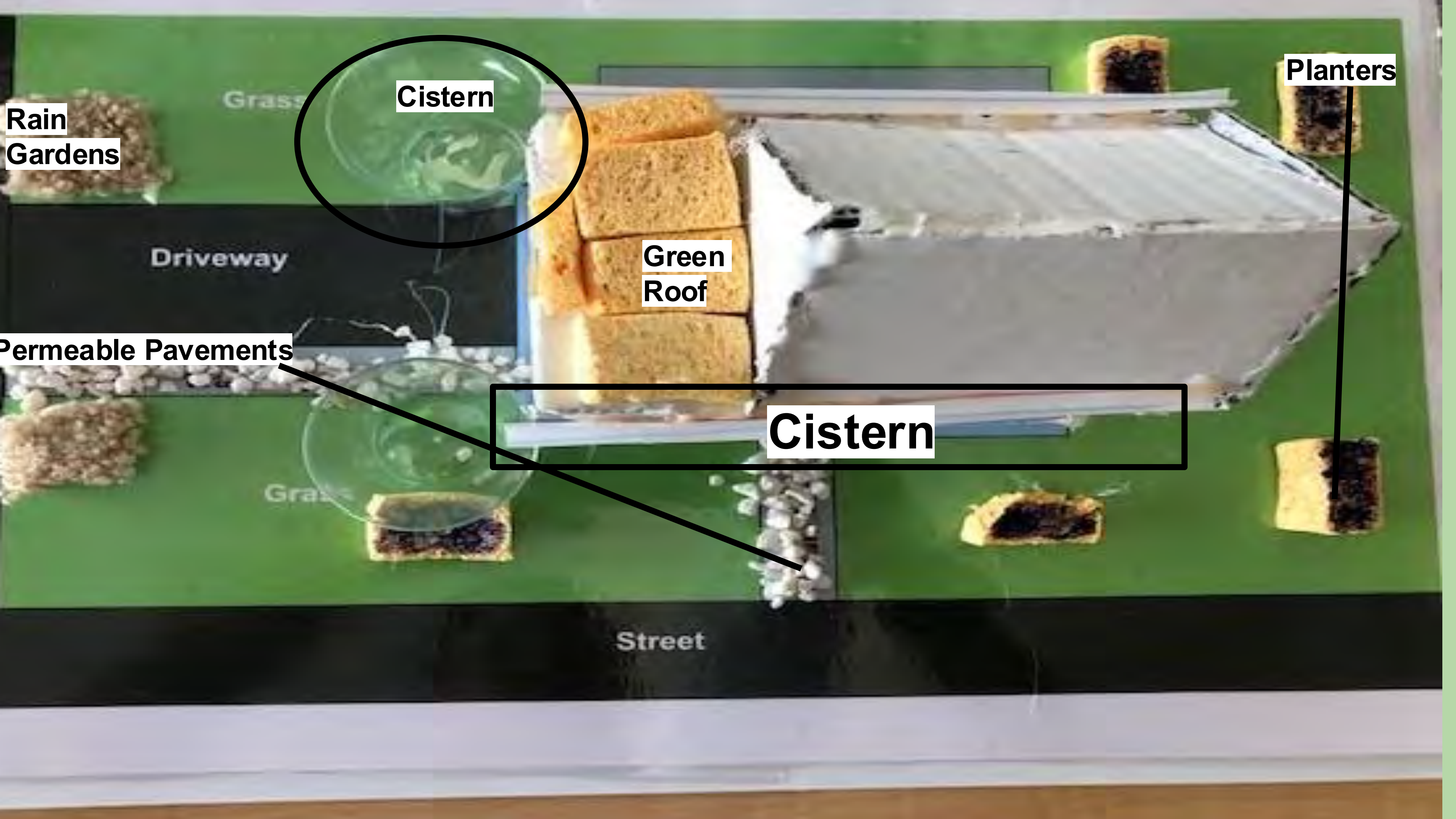
Flooding Engineering Design Project

Design Brief:	Humans cannot eliminate flooding but can take steps to reduce the overall negative impact.
Engineering Problem:	Many Residential properties have Stormwater Runoff systems that move water off the property as quickly as possible into our local waterways which can increase the risk of flooding.
Solution:	Humans can install green infrastructure that will allow for more infiltration and slow the water down which will reduce the risk of flooding.
Task:	Redesign a residential property drainage system with green infrastructure to slow down water and allow for more infiltration which will reduce the negative impact of flooding

[Testing Video]

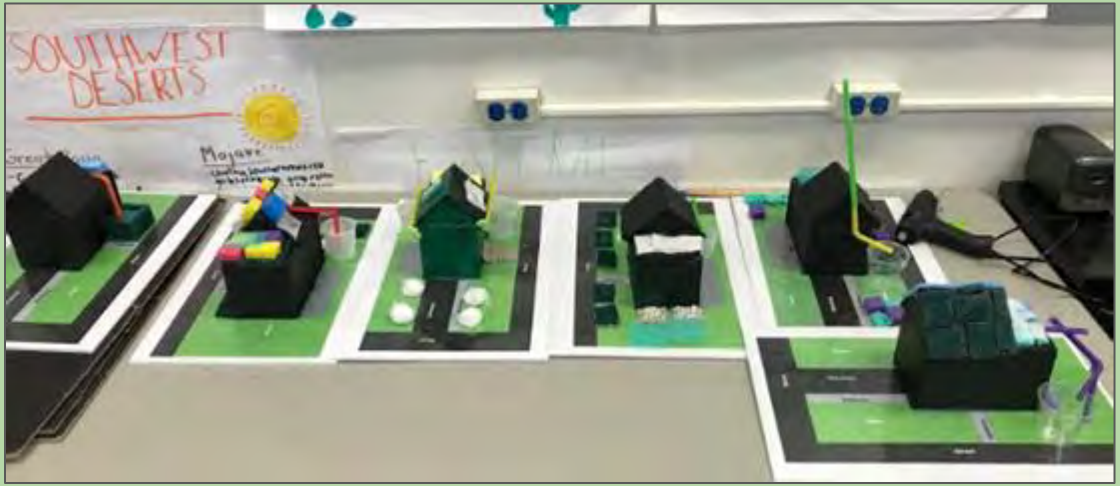
Model Break Down

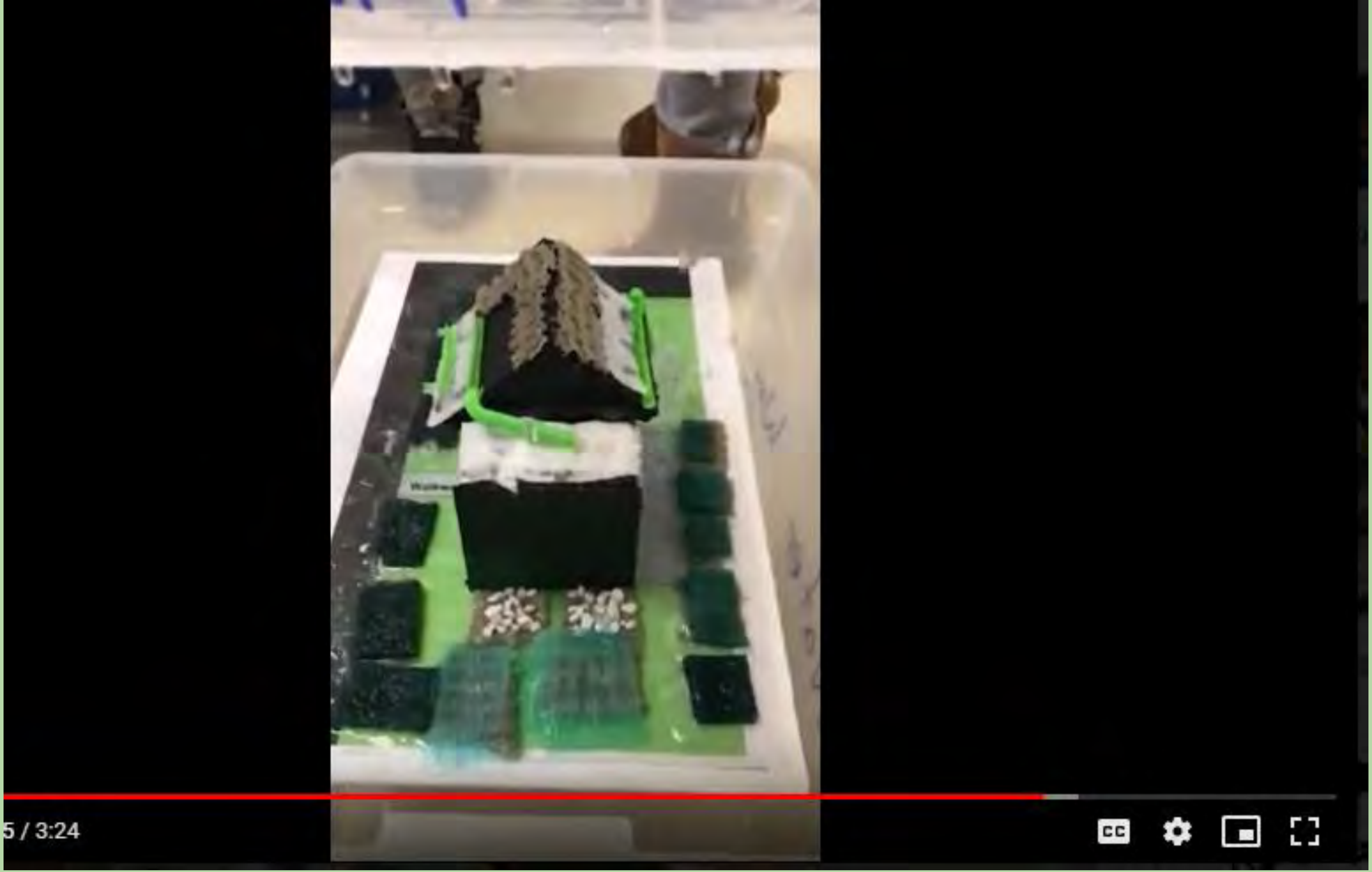

Patio
Street
Driveway
House goes here!
Walkway
Walkway
Street


Rain Gardens
Grass
Cistern
Planters
Driveway
Green Roof
Permeable Pavements
Cistern
Grass
Street

Erin, Saaketh, and Katelyn


BELIEVE
If you can dream it, you can do it.


SOUTHWEST DESERTS
Mojave



https://drive.google.com/drive/my-drive

4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Flood Investigation (Green Infrastructure)

Target Question: Which Solution is most effective?

Directions: Use this table to organize your testing evidence.

Evidence

Team Name	Quantitative	Qualitative	[illegible]	Reasoning *explain how you used the evidence to rank each solution
Hunter	950 ml	The water hitting the roof of the house was captured by a rain barrel	RANK	This group was most effective because...

Record evidence from these teams

Evidence

Team Name	Quantitative	Qualitative	RANKING	Reasoning *explain how you used the evidence to rank each solutio
Alex	1,100 ml.	Most of the water flowed into the driveway, street, and open area.	3	This team could do a better job because they needed to put more infiostutere and they need to make observations th are positive.
Connor	1,090 ml.	The guters from the rain barrels helped flow the wate into the barrels.	2	This team did a great job but they could do better because they needed to add more to the rain garam. Also they needed less rain barrels.
Shona	910 ml.	The bioswale helped alot because it absorbed some of the watr.	1	I think this team did the best job because they said that their bioswal helped alot and they did not have much water in the roadways. Also, looki at their design I can tell that they put alot of thought and effort into the project.

Statement Specific Rubric: : Generate Multiple Solutions

<table>
<tr><td colspan="3">Generates and compare multiple solutions that solve a real world problem *evidence focus is on patterns and cause and effect relationships</td></tr>
<tr><th>1</th><th>2</th><th>3</th></tr>
<tr>
<td>Is unable to evaluate the merit a solution with evidence</td>
<td>Is able to evaluate the merit of one solution with one type of evidence to support their claim

<u>Accuracy</u>
Claim: Is accurate or logically connected to one type of evidence (observation)
*logically connected means the claim makes sense based on the students thinking but may not be accurate

*can be applied to content mastery evaluation</td>
<td>Is able to evaluate the merit of more than one solution using multiple types of evidence to support their claim

<u>Accuracy</u>
Claim: Is accurate and fully supported by their evidence

*can be applied to content mastery evaluation</td>
</tr>
<tr><td colspan="3">Teacher Generated Example</td></tr>
</table>

Air Pollution

3-5-ETS1 Engineering Design

3-5-ETS1 Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.

- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

ETS1.B: Developing Possible Solutions

- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)

ETS1.C: Optimizing the Design Solution

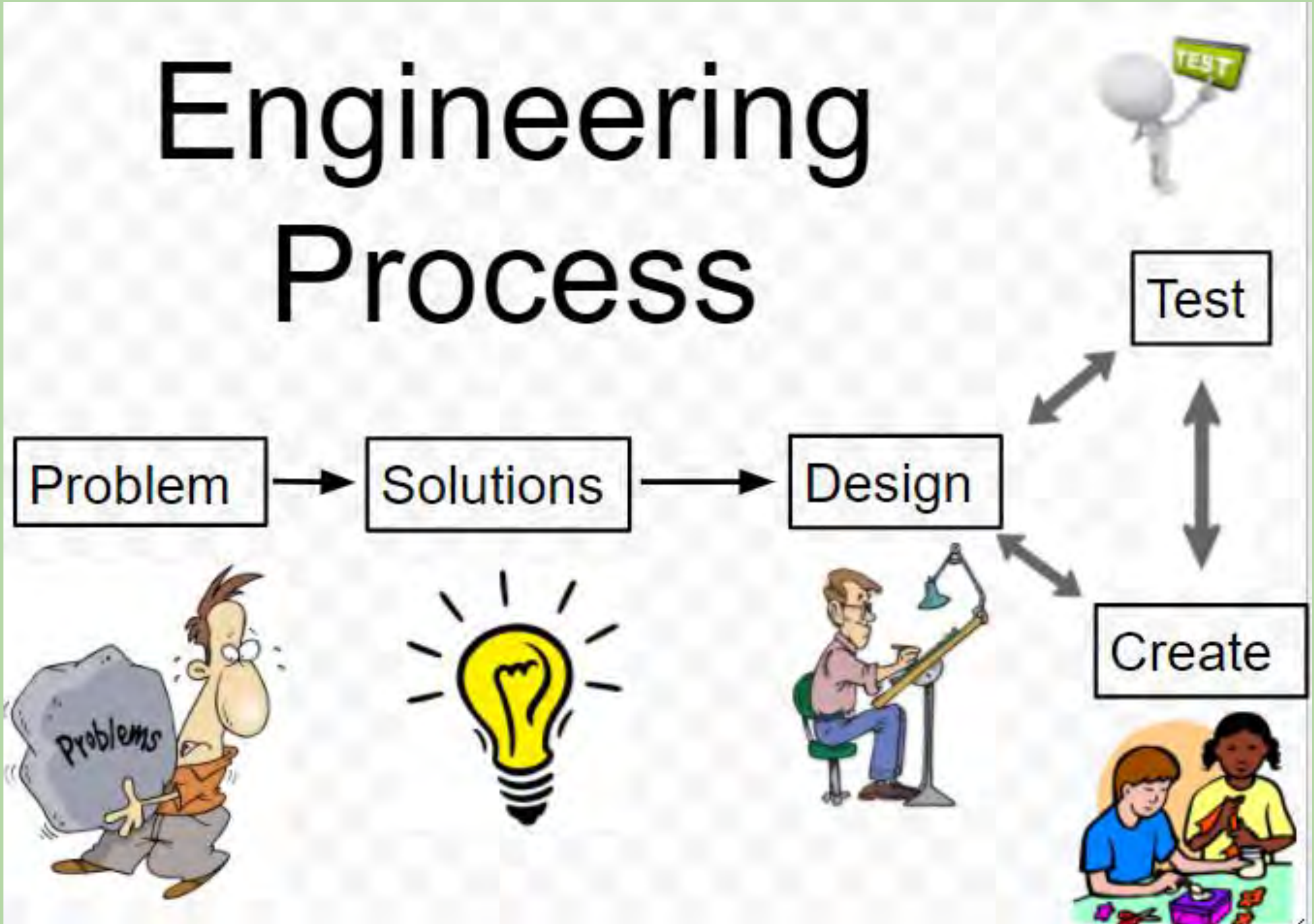
- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)

Crosscutting Concepts

Influence of Engineering, Technology, and Science on Society and the Natural World

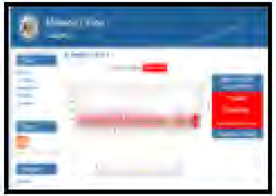
- People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)
- Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

Connections to 3-5-ETS1.A: Defining and Delimiting Engineering Problems include:


Engineering
Process
TEST
Test
Problem
Solutions
Design
Create
Problems

https://datadrivendj.com/tracks/smog/

Air Pollution Engineering Design Project



<table>
<tr><th colspan="2">Problem</th></tr>
<tr><td colspan="2"></td></tr>
<tr><th>Useful Questions</th><th>What could be causing the problem?</th></tr>
<tr><td></td><td></td></tr>
</table>

Air Pollution Engineering Design Project

Design Brief:	Due to China's economic growth over the past three decades, many Chinese cities have seen major increases in **population**, **manufacturing** as well a major reliance of **coal fired power plants.** These three factors have contributed to significant air quality issues in many of China's cities. While the Chinese are working on legislation to help improve air quality across China there are some unique solutions that are being used to combat this issue. Your team will be tasked with using a green method to help reduce the negative impact of population growth, manufacturing and motorized vehicles on Chinese cities.
Problem:	An increase in **population**, **manufacturing** and **coal fired power plants** in Chinese cities are causing harmful levels of air pollution.
Task:	Design and build a working model of a skyscraper that serves as a **vertical forest** to help improve the air quality in cities across the globe that are battling with Air Pollution issues similar to that of China.

Criteria/Constraints

1. The skyscraper must have plants that can be used to help filter toxins from the air *we will use Wheatgrass as our plant
2. Sky Skyscraper must be approximately 90% closed
3. Sunlight and Water must be able to get to your plants **they will be placed by a window for testing*
4. Plant locations must be able to support .75 inches of soil
5. The skyscraper must be at least 3 levels
6. Each level must have plants on at least 2 sides
7. You may only use "lumber" from the lumber yard, no larger pieces will be provided.

Your initial Design Idea(s)

A NEW KIND OF BUILDING An artist's rendering shows the Nanjing Green Towers, which will have 1,100 trees planted on their balconies.

Vertical Forest Data (2019)

3KR

Number	Mass 2/14	Mass 3/27	Biomass (plant mass)
1	301 g	542 g	241 g
2	317 g	516 g	199 g
3	343 g	455 g	112 g
4	301 g	491 g	190 g
5	205 g	314 g	109 g

China Air Pollution Vertical Forest Investigation

Target Question: Which Design will clean the air most effectively?

Team Name/Building Name	Sketch of Design	Mass 2/14	Mass 3/27	Ranking	Reasoning

Erosion Control Methods

2-ESS2 Earth's Systems

2-ESS2 Earth's Systems

Students who demonstrate understanding can:

2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.* [Clarification Statement: Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land.]

2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area. [Assessment Boundary: Assessment does not include quantitative scaling in models.]

2-ESS2-3. Obtain information to identify where water is found on Earth and that it can be solid or liquid.

Land and Water Engineering Project

Problem:	Water changes Earth's surface, which can have a negative effect on living things
Solution:	Humans can use strategies to minimize the impact that moving water has on land.
Task:	Students must design their own system using student developed strategies to slow the movement of land

Criteria:

1. Your system must slow the process of how water is changing the land
2. Must use evidence from the investigation to help you with this task
3. Must test your first design and modify based on your test results
4. Plants must be able to grow in the area where you are installing your system **think, what do plants need?*

Constraints:

1. May only use the provided materials
2. Must be completed in the time allowed

Silt Fencing

Erosion Control Blanket

Mulch Sock

Team:____

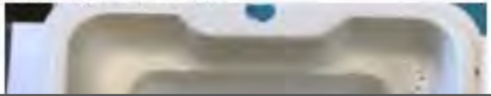
Design: Draw a sketch of the strategy your team will create to minimize the impact that moving water has on land.

First Design

Materials:

____

Sketch of your Design: *birds eye view



Soil Observation: Draw how the soil looks after the simulated rain.

Water: *circle your response: Clear Cloudy Muddy

How can you change this design to make it better?

Water: *circle your response: Clear Cloudy Muddy

How can you change this design to make it better?

Name:____

Evaluation of Designs

Claim: Which system is most effective?____________________________________

(you must use evidence from the team's testing, see evidence slips)

Reasoning: Why do you think this?

3-LS1 From Molecules to Organisms: Structures and Processes

3-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. [Clarification Statement: Changes organisms go through during their life form a pattern.] [Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop models to describe phenomena. (3-LS1-1) --- ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Science findings are based on recognizing patterns. (3-LS1-1)	**LS1.B: Growth and Development of Organisms** • Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (3-LS1-1)	**Patterns** • Patterns of change can be used to make predictions. (3-LS1-1)

Connections to other DCIs in third grade: N/A

Articulation of DCIs across grade-levels: **MS.LS1.B** (3-LS1-1)

Common Core State Standards Connections:

ELA/Literacy –

RI.3.7 Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur). *(3-LS1-1)*

SL.3.5 Create engaging audio recordings of stories or poems that demonstrate fluid reading at an understandable pace; add visual displays when appropriate to emphasize or enhance certain facts or details. *(3-LS1-1)*

Mathematics –

MP.4 Model with mathematics. *(3-LS1-1)*

3.NBT Number and Operations in Base Ten *(3-LS1-1)*

3.NF Number and Operations—Fractions *(3-LS1-1)*

Link to project

The Dam Project