Rainwater Harvesting

Lesson 9: System Design and Improvement

INTRODUCTION

Lesson 9 will take at least two class periods for students to design, revise, and share their rainwater harvesting system. Students will need to draw on data they generated in the previous lessons to design their own system and provide constructive feedback to their peers.

Teaching Strategies

In this Lesson, students will continue working through the Engineering Design Process. They will continue to learn how to Plan, Create, and Improve their design.

The concept of Continuous Improvement is introduced to expand their understanding of how the Engineering Design Process works in the real world.

Students continue to use the DSRP thinking framework to deepen their understanding.

OBJECTIVES

- **BUILD THE SYSTEM:** Design a rainwater harvesting system using the engineering design process that meets the criteria and constraints identified by previous research.
- **TAKE A PERSPECTIVE:** Review peers' work and provide helpful and critical feedback.
- **TAKE A PERSPECTIVE:** Use peer feedback to revise work and improve designs.

MATERIALS AND EQUIPMENT

- Worksheet: *Your Rainwater Harvesting System Worksheet*
- Rubric: Rainwater Harvesting System Design Rubric
- Graph paper or other paper for student designs

LESSON SUMMARY

In this lesson, students will compile their data using the *Your Rainwater Harvesting System Worksheet* instructions. They will also need their Site Maps (to scale), Basin Drawings, their supply and demand calculations, and all their notes from the previous lessons. They will design their rainwater harvesting systems and provide their peers with a helpful critique.

The Rainwater Harvesting Unit is adapted with permission from the Arizona Project WET, Rainwater Harvesting Aqua STEM Program.

PRESENTATION GUIDE

Connect to the Unit

In Lesson 8, students learned to use data, mathematics, and computational thinking to size infiltration basins to optimally meet the engineering design challenge. They now understand that infiltration basins are a key part of their rainwater harvesting system and are essential to meeting their plants’ water requirements.

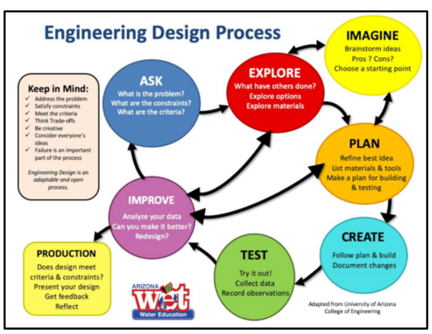
Launch the lesson

In this lesson, students will complete the following tasks:

- Compile their data and think through all parts of their system.
- Design their system based on the criteria and constraints.
- Test their design on their classmates.
- Improve their system utilizing peer feedback to create the best design based on the criteria and constraints.
- Present their system designs to classmates.

Remember the driving question…

How will you design a passive rainwater harvesting system that will provide shade and sustain your plants year-round through the most efficient use of available water?

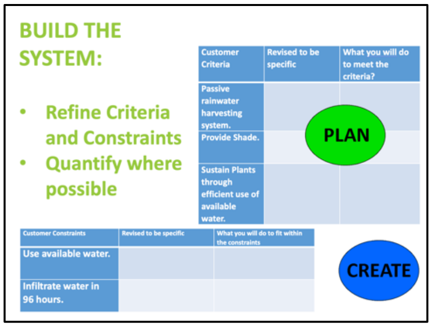


Where are we in the engineering design process?

We have been Asking questions, Exploring, Imagining and Planning regarding this engineering project. In this lesson, we move forward in the Planning stage and then begin the Create and Test phases of the Engineering Design Process.

Students will need at least two class periods to design their system:

1. Students will compile their data using the *Your Rainwater Harvesting System Worksheet* instructions. They will also need their **Site Maps (to scale), Basin Drawings, their supply and demand calculations and all their notes**.
2. They will begin to design their rainwater harvesting systems.

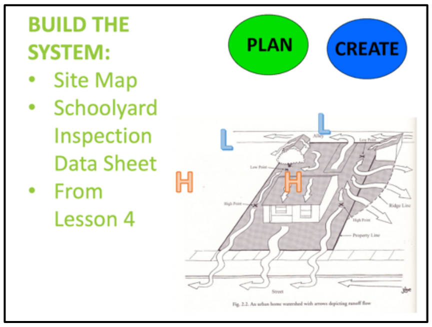


Review the parts of the worksheet with the students. The next 10 slides cover four key parts of the worksheet.

As you circulate the room, ask students questions about how their design accommodates the data they developed throughout the explorations.

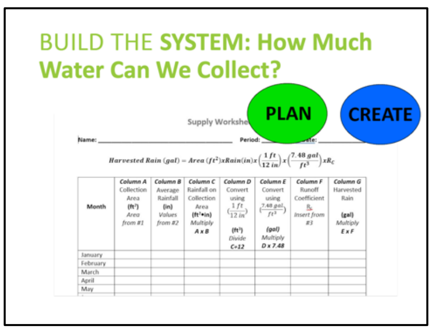
Emphasize that designs require data-driven decisions, not guesses.

Have students revisit their criteria and constraints. They've been developing and refining these lists throughout the unit, so now is the time to review and update them. If students have recorded their criteria and constraints in notebooks or on paper in the classroom, ask them to refer to those. There is also a table in the worksheet where they can organize, add to, and refine their lists based on what they've learned so far. Encourage them to adjust as needed to reflect new insights from their design work.



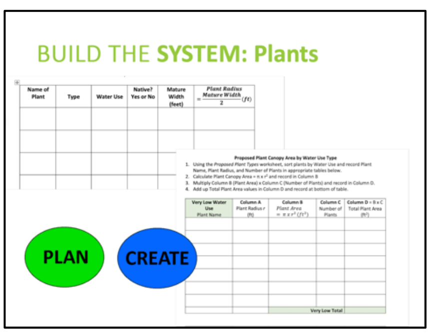
Site Map

Students should check the map of the landscape site from lesson 4. All system components will need to be within the boundaries of the school grounds.



How Much Water Can We Collect?

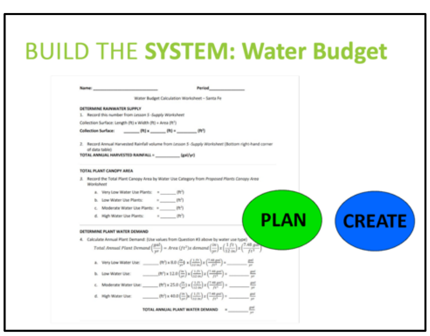
Students should include their calculations of the amount of water that they can collect from the surface area.



Plants

What plants are they proposing?

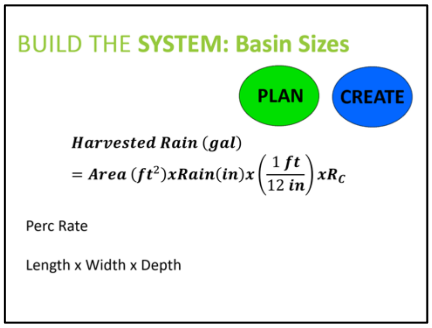
Include Plant types, Quantities, Sizes, Watering Requirements.

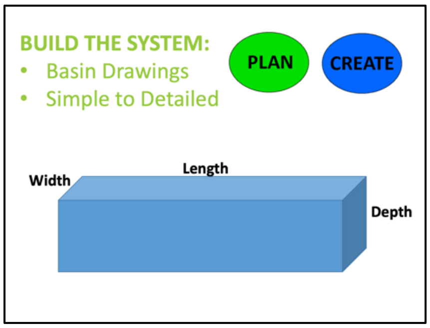


Water Budget

Are they meeting the plant demands with the harvested water?

How efficient is the system? Did they quantify it?





Basin Sizing

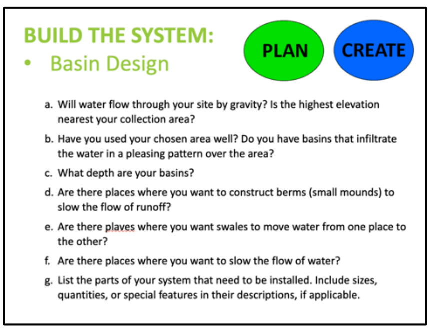
What sizes are their basins?

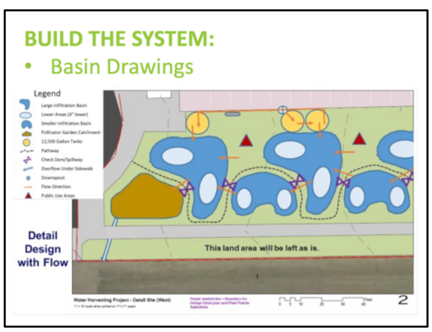
- What are the basin dimensions?
- Are their basins able to handle a 100-year storm event? If not, what percentage of a 100-year storm event is it handling?

Did they show their math?

How are they using overflow?

Are they meeting the constraints of ensuring safety, avoiding interference with utilities, and not causing unwanted flooding?



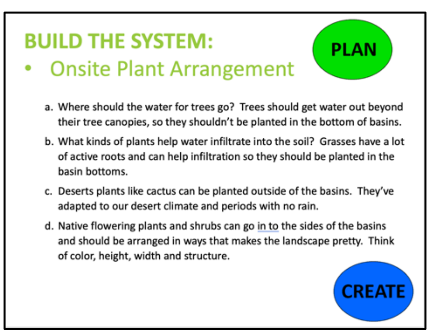


Basin Design

Check your to-scale drawings from Lesson 8 and either revise them or start a new draft. Be sure to include: a map with an overhead view of your site and a cross-sectional view showing depth and slope.
Make sure all parts are clearly labeled.

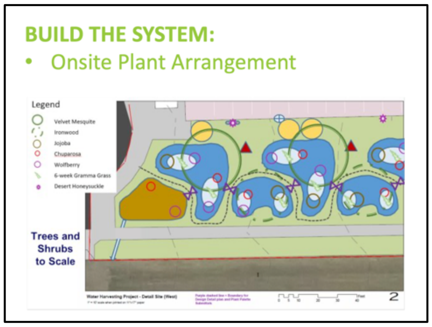
As you revise or draw, consider the following questions:

- Will gravity help move water through your site? Is the highest elevation located near your collection area?
- Are you using your available space effectively? Have you arranged your basins in a way that spreads water across the site?
- What are the depths of your basins?
- Are there areas where you need to build berms (small mounds) to slow runoff?
- Are there places where swales could help direct water from one area to another?
- Are there spots where you need to slow water down? (Consider using strategies like One Rock Dams or Media Lunas.)
- Make a list of everything that needs to be installed. Include sizes, quantities, or special design features where appropriate.

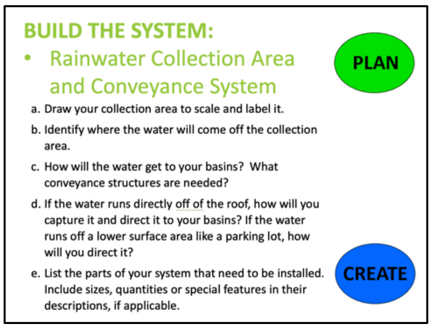


Onsite Plant Arrangement

Use the Basin Drawings or on another piece of graph paper, plan your plant placement within and around the basin paying attention to plants water needs.



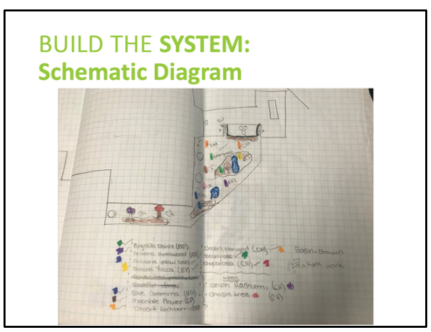
- Where should the water for trees go? Trees should get water out beyond their tree canopies, so they shouldn't be planted in the bottom of basins.
- What kinds of plants help water infiltrate into the soil? Grasses have a lot of active roots and can help infiltration, so they should be planted at the bottom of basins.
- Deserts plants like cactus can be planted outside of the basins. They've adapted to our arid climate and periods with no rain.
- Native flowering plants and shrubs can go into the sides of the basins and should be arranged in ways that makes the landscape pretty. Consider color, height, width, and structure.



Collection Area and Conveyance Diagram

On another piece of graph paper, plan your rainwater conveyance system from your collection area.

- Draw your collection area to scale and label it.
- Identify where the water will come off the collection area.
- How will the water get to your basins? What conveyance structures are needed?
- If the water runs directly off the roof, how will you capture it and redirect it to your basins? If the water runs off a lower surface area like a parking lot, how will you direct it?
- List the parts of your system that need to be installed. Include sizes, quantities or special features in their descriptions, if applicable.

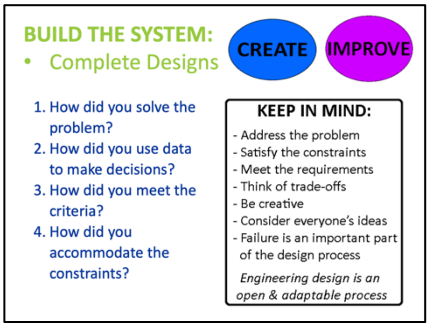


What makes a good design?

By preparing a schematic drawing, students should have a better understanding of the physical components involved in their system. They have already created maps of their systems using a map view or aerial perspective.

Ask students why they think it's important to use schematic drawings and overhead view design layouts: "What are the benefits to each type of diagram?"

A schematic drawing shows the parts of the system without too much concern for scale and placement. In this type of diagram, it is important to show all of the system components. These components should be listed and described on the worksheet.

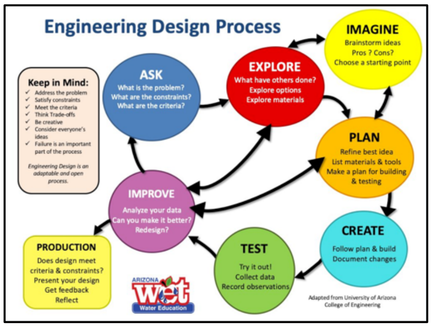


Presentation

Prepare to present your design. In addition to your maps, drawings, and diagrams, your presentation should include words and numbers to answer the following questions:

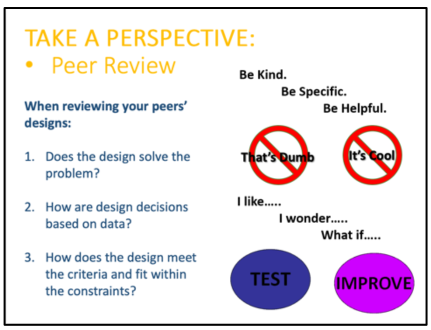
1. How did you solve the problem?
2. How did you meet the criteria?
3. How did you accommodate the constraints?

Describe at least one decision you made to improve your design or better meet the criteria and accommodate constraints.



TEST through peer feedback

Where are we in the engineering design process? Previously we were Planning and Creating a rainwater harvesting system. In this lesson, we began the Testing phase of the Engineering Design Process. By conducting a test, we can improve the final product design.

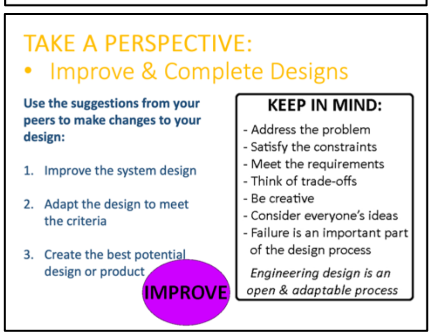


TAKE A PERSPECTIVE

• Review peers' work and provide helpful feedback.

The design review is a mental test of the system. Peer experts will examine the design plan and think through how it works. They will offer helpful feedback regarding how to improve the system. Helpful feedback is specific and kind. Starting sentences with the phrases on this slide will help students to share useful and respectful feedback.

Conduct a "Gallery Walk" for students to explore each other's designs and make CONSTRUCTIVE CRITICISM on post it notes.

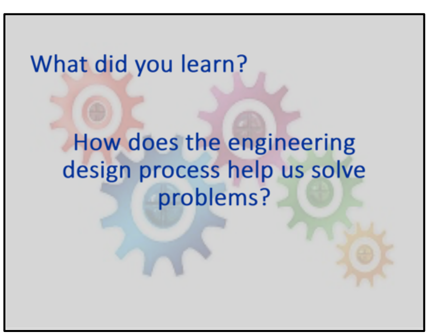


TAKE A PERSPECTIVE

• Improve & Complete Designs

Continuous improvement is a model or process which promotes the idea that making regular, smaller changes can lead to large improvements in function. Encourage students to look for opportunities to continue to improve their system designs based on the feedback they received. How can they adapt them to create the best product?

Once they have completed their revised designs, students should prepare for their final presentations.



Conclusion

How does the engineering design process help us solve problems?