**Lesson 4: Modeling a Rain Garden**

**Problem statement:** How can we reduce the amount of pollutants distributed by storm-water in our community from entering our region’s waterways so that marine animals are not contaminated?

**Learning objectives:** This lesson connects to the problem as students design a solution that stops pollution from entering our waterways. Students will use engineering, science, and math to create a model of a rain garden that prevents flooding, erosion, and excess water drainage on a scalable level.

**Lesson standards (**Source: [Next Generation Science Standards](https://www.nextgenscience.org/search-standards)**)**

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| **Standard** | **How the Standard Will Be Assessed** |
| [**Performance Expectation 3-5-ETS1-2: Engineering Design**](https://www.nextgenscience.org/pe/3-5-ets1-2-engineering-design) **-**  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. | Detailed design sketches, final model of rain garden, and the reflection worksheet. Classroom discussion on what solution worked best and why. |

**Soft skills: (**Source: [Social Emotional Learning Standards, Benchmarks, and Indicators](https://www.k12.wa.us/sites/default/files/public/studentsupport/sel/pubdocs/Appendix%20D%20Standards%2C%20Benchmarks%20Indicators.pdf)**)**

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| **Soft Skill** | **Standard** |
| Communication | STANDARD 2 - SELF-MANAGEMENT – Individual has the ability to regulate emotions, thoughts, and behaviors. |
| Collaboration | STANDARD 5: SOCIAL MANAGEMENT – Individuals have the ability to make safe and constructive choices about personal behavior and social interactions. |
| Critical Thinking | STANDARD 1: SELF-AWARENESS – Individuals have the ability to identify their areas for growth, and potential external resources and supports. |
| Creativity | STANDARD 6: SOCIAL ENGAGEMENT – Individuals have the ability to consider others and show a desire to contribute to the well-being of the school and community. |

**Prerequisite skills:**

* Students will need to know the basics of the engineering process. They should know that engineers define a problem, develop a solution, and optimize the solution.
* Students will need to knowhow to measure or estimate liquid volume.
* Students will need to know place value, and adding and subtracting within 100. You may increase the difficulty of this skill, if desired.
* You may want to pre-teach vocabulary from videos: rain barrel, engineering process, green infrastructure, etc.

**Locally and/or personally relevant for students:** This lesson teaches the impact of the clarity of water and absorption of local water by designing a solution that mimics the plants and soil in a rain garden. All of our students need to think about clean, filtered water for the environment and their local community. This lesson allows all students to engage in a lesson that is simulating the ways engineers design solutions for the environment.

**Connections to career and educational pathways:** Students will practice dividing up responsibilities for carrying out an investigation. Each job will simulate a real job that would accomplish each task.

**Materials:**

* Cotton Balls
* Sand
* Sponges (Optional)
* Dirt
* Mulch
* Coffee filters (optional)
* Rocks
* Pebbles
* 5 Square plastic containers with a hole at the bottom (storage containers will work nicely)
* Bucket to collect “runoff”
* Trowels or spoons (1-5 per group)
* Towels (for spills)
* Watering Can, or container to simulate water
* Measuring container, such as a beaker or graduated cylinder to measure water (optional)
* Chart paper (optional)

**Time required:** approximately2-3 days. 120 minutes minimum.

* Day 1: Assign groups, help students through the planning process, and give group expectations.
* Day 2:Students will “buy” materials using the attached budget, construct their rain garden, and complete the first trial.
* Day 3 (optional): Connect designs to a real rain garden location at the school or time to optimize their rain garden model and reflect on results.

**Grouping of students for instruction:**

Students will need to be in groups of 4-5. Print out the job list so that each student knows their specific job. Roles could include:

1. **Landscape Designer:** The landscape designer will draw the design with detailed labels for their group sketch.
2. **Performance Analyst:** The design engineer will help the group communicate their design results with the class, as well as help the group communicate effectively about the design.
3. **Product Safety Engineer:** The product safety engineer will make sure that safety protocol is followed, and will safely collect materials.
4. **Surveyor:** The surveyor will write detailed observations for each test, and will share findings with their group for further trials.
5. **Project Manager:** The project manager will make sure that the group is completing all parts of the investigation, as well as make sure everyone is doing their roles and sharing the work.

**PBL Procedure: Day 1**

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| **Part 1: Watch Engineering Videos** | |
| **Teacher** | **Student** |
| Use the following video to help students understand what the engineering process will look like:  <https://vimeo.com/238855219>  After the video, begin a conversation among students about what they observed.  Question Suggestions:  How did Juniper define the problem?  How did Juniper develop solutions?  When did you notice Juniper optimizing solutions?  What failure points did she discover? How did she adjust? | Individually, students will answer or write down answers to questions during the video. Partner groups will discuss what they noticed during the video. |
| Next, show the first 6 minutes of this video to help students get ideas on how they will model a rain garden in their tub:  <https://www.youtube.com/embed/9Kti4HJ45BM>  The video is lengthy, so you may want to stop the video and allow students to think and add to the chart several times during this part of the lesson. You may want them to write on sticky notes and put them on a chart to get them up and moving.  Ask Students: What can you use from this video and what you have learned so far to develop a rain garden that controls water flow during a “heavy rain storm”? | Students answer the question about the construction of a rain garden. They will add to the chart.  Students will start to come up with thoughts on design solutions for their model. They may begin to sketch some ideas. |
| **Part 2: Design a Model Sketch** | |
| **Teacher** | **Student** |
| Assign students jobs and split the class into groups of 4-5 students.  Assign each student a role during this investigation. This will help with classroom management and give all students an opportunity to participate. It will also help you assess their ability to maintain roles within a group. | Students will move to a table with their group to begin a conversation about possible designs. |
| Ask students to brainstorm group expectations to follow and chart them on paper.  If possible, connect each idea to the soft skill standards for this lesson. Write each soft skill next to each idea.  You may want to pass out chart paper and markers to give students a place to document their ideas. | Students will think and share about what makes a successful group. They will process ideas with their group. |
| Pass out budget information and storage tubs to each group.  Then, facilitate conversations and look for soft skills, aiding groups when needed.  See the teacher “talk moves” sheet to document group soft skills. | Students will begin to share sketches with teammates. Then, the landscape designer will start creating a group sketch based on thoughts about individual sketches. They will also discuss their budget constraints, deciding which materials they would like to use. Project managers will make sure that each person is correctly performing their role and providing advice to the group. |
| Collect brainstorms and budgets from each group.  Each group’s performance analyst will share out one idea. | Performance analysts will share their group’s idea. |

**PBL Procedure: Day 2**

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| **Part 1: Construct Model Rain Garden** | |
| **Teacher** | **Student** |
| Once students are ready and have correctly budgeted for their rain garden, pass out materials to each group to begin construction.  Stay near the materials so that you can pass them out to each product safety engineer. Make sure the materials are organized so you may quickly pass them out. | Students will fill out their budget sheet as a group and the project safety engineer will bring their budget sheet up to the teacher.  Project managers will make sure that everyone is helping build and encouraging all students to participate. |
| Continue to facilitate discussion among groups as well as document soft skills on the “Teacher Talk Moves” worksheet from the previous day. | Students will continue to build rain gardens, using the jobs outlined to help them work as a team. Project managers will keep track that each student is following their role. |
| **Part 2: Test Model Rain Garden** | |
| **Teacher** | **Student** |
| Provide the “rain” by using a watering can. Make sure that you have enough rain to provide “flooding” capabilities, but not too much where it will overflow or make it difficult for students to see their design working. | Students will test out their rain garden to see how well it contained water.  They will look for erosion (losing structure of their design).  The group surveyor will also write down detailed observations while water is being soaked up by the garden and they need to determine whether the water is flooding inside the tub. |
| Evaluate the effectiveness of the garden based on the amount of water leaking through the rain garden spout, erosion inside the tub, and flooding within the tub. | One student, or each group product safety engineer, will measure the amount of water that goes through their rain garden. (Optional: students could use graduated cylinders or beakers to learn how to measure in mL)  The surveyor will record their water amount on a class chart (optional, as students could also just look visually at the amount and estimate) |
| **Part 3: Share Out Results** | |
| **Teacher** | **Student** |
| Debrief with the class about the results. Record answers for reflection.  What worked? What didn’t work? Do you think your team worked together well? Why or why not? How could you improve the design process for a second trial? | Students will discuss ideas with groups and the performance analyst will share their team’s results. |

**PBL Procedure: Day 3 (optional):**

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| **Test Out New “Optimized” Designs** | |
| **Teacher** | **Student** |
| Pass out materials for designing a second rain garden. Keep groups the same. | Students will design a second rain garden model with their group. |
| Guide student thinking by reminding them of their reflections on the previous day.  You may want to keep a poster of the responses visible so your students may refer to previous ideas visually. | When students are finished, they will try out an additional rain garden design. |
| Test designs again. | Students will note any improvements or difficulties. |
| Pass out a data reflection sheet to share understandings. | Students will discuss the questions with their group and the surveyor will record their answers. |
| Debrief with the class about the results as you did for the previous day. Record answers for reflection.  What worked this time? What didn’t work? Do you think your team worked better today? Why or why not? What would you try next to optimize your rain garden? | Students will discuss ideas with groups and the performance analyst will share their team’s results. |

**Accommodations:**

* **English Language Learners:**
  + Partner students with other same language peers, if possible, to help them communicate with their groups more effectively.
  + Use google translate to communicate ideas while planning rain garden models.
  + Assign students as landscape designer, product safety manager, or surveyor.
* **Special Education:**
  + For visually impaired students, assign the role of project manager or performance analyst.
  + Allow students to communicate as a group to document budget costs, trials, and data reflection.
  + Write responses collaboratively as a group.
  + Use 4-5 word responses or sentence stems as opposed to composing complete sentences.
* **Highly Capable:**
  + Provide more challenging numbers in rain garden budgets.
  + Provide a homework assignment where the student will have to create and present a graph of the class’s rain garden data.

**Extensions:**

* Day 3 is a great time to introduce fair trials, control variables, manipulated variables, and responding variables. When optimizing their solutions, you may want to reflect on how to conduct the test fairly, to know which variable helped improve the design.
* Islandwood School in Seattle Public Schools has additional curriculum materials on their website to model the use of a rain garden in a specific area of your school (using tin foil, plants, and dirt in a storage bin). <https://islandwood.org/community-waters-science-unit/>
* The teacher may want to change the numbers in the Budget handout to decimals, or more challenging numbers, depending on the need of your students. You could use the budgeting sheet as additional practice with fractions, decimals, and place value.
* Another possible math extension would be to create a graph of the classroom data, or find the average of the data.

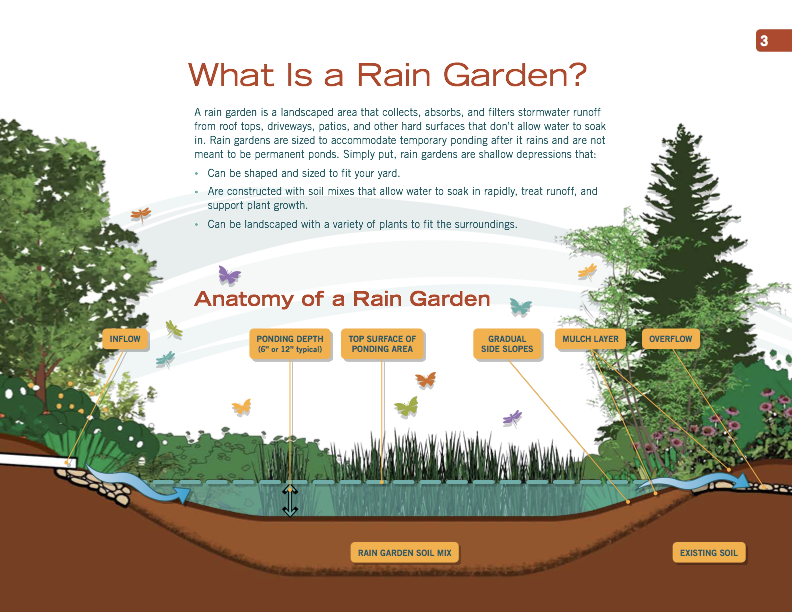
**Assessment:**

* Worksheet: Reflection of soft skills
* Calculation of cost of rain garden supplies (constraints and criteria)
* Collection of data on trials and water retention (documentation of criteria for success)
* Data and Results Reflection (engineering design)

**References/Resources:**

* Instructional Plan Created during the 2019-2020 school year by Verónica West, Jenn McNease, Erin Wells, and Tim Rhoades of the Northshore School District in Washington State as part of their work with the Washington Alliance for Better Schools (WABS) ACCESS STEM program.
* Instructional Plan Consultants (not responsible for the content of this instructional plan):
  + Steve Harvey, teacher, Everett School District in Washington State
  + Linda Richard, Associate Director of Instructional Leadership, Washington Alliance for Better Schools (WABS)
  + Mick Shultz (Port of Seattle), Lisa Hiruki-Raring (NOAA-Alaska Fisheries Science Center)

Page 3 from [“Rain Garden Handbook for Western Washington”](https://fortress.wa.gov/ecy/publications/documents/1310027.pdf)



This resource will be a valuable tool for students as they plan and construct their rain garden models. You may want to print out one per group as a guide while they build their own.

Page 7 from [“Rain Garden Handbook for Western Washington”](https://fortress.wa.gov/ecy/publications/documents/1310027.pdf)

On this page, the steps to building a rain garden are layed out. You may want to show this before you begin your model to demonstrate the process for a real rain garden. 

**Teacher Talk Moves**

Teacher Directions: Print a sheet for each group prior to teaching Lesson 4. Use these sheets to document progress towards SEL standards.

**Group: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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| **Teacher** | | | **Student**  **Responses**  (Use initials) |
| **Soft Skills and What to Look For** | **Standard** | **Guiding Question Suggestions** |
| Communication-   * Emotional Regulation * Inclusion | Individual has the ability to regulate emotions, thoughts, and behaviors | How have you made your group a safe place for ideas?  What can you do to make sure everyone feels important? |  |
| Collaboration   * Following Assigned Roles * Active Listening | Individuals have the ability to make safe and constructive choices about personal behavior and social interactions. | What is your group doing to make sure everyone is following their jobs?  What are you doing to listen to one another’s ideas? |  |
| Critical Thinking   * Growth Mindset * Working towards a common goal | Individuals have the ability to identify their areas for growth, and potential external resources and support. | What are you doing to solve this problem today?  How will you be successful in meeting your goals for this design? |  |
| Creativity   * Positive contributions to school and community | Individuals have the ability to consider others and show a desire to contribute to the well-being of the school and community. | Why is creating this model important to our school and community? |  |

Team: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Budget: Rain Garden

Total Spending: $100

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| --- | --- | --- | --- |
| Item | Cost | Amount | Quantity |
| Dirt | 9 | 6 cups |  |
| Mulch | 13 | 2 cups |  |
| Rocks | 25 | ½ cup |  |
| Pebbles | 28 | ½ cup |  |
| Sand | 32 | 1 cup |  |
| Sponge | 36 | 1 |  |
| Cotton balls | 22 | 10 |  |
| Coffee filter | 24 | 2 |  |
| **Total:** |  |  |  |

Classroom Rain Collection Data

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Team 1** | **Team 2** | **Team 3** | **Team 4** | **Team 5** |
| **Trial 1 (mL)** |  |  |  |  |  |
| **Trial 2 (mL)** |  |  |  |  |  |

Team: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Data and Results

1. Was your rain garden successful? (think about the amount of flooding and erosion)
2. Which trial did you find was more successful? Why?
3. Did your group successfully communicate, or share ideas? Why or why not?
4. How does communication help you when completing a task?
5. Why is it important for scientists, community members, and others to create rain gardens that work? How does it help the environment?