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| **Lesson Title : Bioremediation** | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **5** |
| **Activity Title: Engineering Design Process (EDP)** |

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| **Estimated Lesson Duration:** | **8-9 days (70 minutes)** |
| **Estimated Activity Duration:** | **4-5 days (70 minutes)** |

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| **Setting:** | **8th grade classroom** |

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| **Activity Objectives:** |

Students will design a plan to safely clean up the ash ponds at Beckjord.

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| **Activity Guiding Questions:** |

* What is the problem?
* What are the available materials?
* What are the criteria and constraints?
* How will we design a plan?
* What kinds of pollutants are in the ash ponds at Beckjord?
* How do you safely clean up the ash ponds?
* What kinds of organisms clean up pollutants in ash ponds?
* What do these organisms need in order to survive?
* How do these organisms reproduce?
* What are the positive and negative impacts on the when we introduce the new organism to environment?
* What types of mutations can occur in the organism?
* How will we present our design?

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| **Next Generation Science Standards (NGSS)** | |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| ☒ Asking questions (for science) and defining problems (for engineering) | ☐ Patterns |
| ☐ Developing and using models | ☒ Cause and effect |
| ☐ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☐ Analyzing and interpreting data | ☐ Systems and system models |
| ☒ Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and conservation |
| ☒ Constructing explanations (for science) and designing solutions (for engineering) | ☐ Structure and function. |
| ☐ Engaging in argument from evidence | ☒ Stability and change. |
| ☒ Obtaining, evaluating, and communicating information |  |

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| **Ohio’s New Learning Standards for Science (ONLS)** |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☒ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| ☒ Demonstrating Science Knowledge **(D)** |
| ☒ Interpreting and Communicating Science Concepts **(C)** |
| ☒ Recalling Accurate Science **(R)** |

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| **Common Core State Standards -- Mathematics (CCSS)** | |
| **Standards for Mathematical Practice (Check all that apply)** | |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):** |

Topic: Species and Reproduction

Standard: This topic focuses on continuation of the species.

Content Statements:

* 8.LS.1: Diversity of species occurs through gradual processes over many generations. Fossil records provide evidence that changes have occurred in number and types of species.
* 8.LS.2: Reproduction is necessary for the continuation of every species.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

* Computers
* 1.2.5a Engineering Design Process (EDP) Graphic Organizer
* 1.2.5b Group Presentation rubric for Powerpoint/Google Slide
* Cooperative Learning Self Evaluation & Peer Evaluation Form (1.2.5c)

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| **Teacher Advance Preparation:** |

* Have students in teams
* Provide computers for research
* Print handouts
  + 1.2.5a Engineering Design Process (EDP) Graphic Organizer
  + 1.2.5b Group Presentation with rubric
  + 1.2.5c Cooperative Learning Self Evaluation & Peer Evaluation Form

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| **Activity Procedures:** |

1. Pass out 1.2.5a Engineering Design Process (EDP) Graphic Organizer
2. Students begin the Engineering Design Process by...
   1. Identify & Define the Problem section on the graphic organizer.
      1. Students developed the essential question and challenge in the beginning of the unit.
      2. Students will help develop the criteria, constraints, and available materials list such as:

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| **Criteria (requirements)** | **Constraints (limits)** | **Materials** |
| * Remove coal ash from pond * Create sales pitch * Overview of organism being used * Positive & negative ramifications of organism being introduced to the environment * Possible mutations of organism * Clean-up safety plan * Careers in bioremediation * Include reliable sources and citations | * Uses bioremediation to clean up coal ash * Remove only one component from th coal ash * Create a presentation and display * Timeline & due date | * Chromebook * EDP Graphic Organizer * Rubric * Video recorder |

* 1. Gather Information
     1. Students will research if there are any existing ideas that can help you in your plan such as toxins in ash ponds. Is there any information you learned during the investigations that may help you solve the challenge? Identify any questions you still need to find answers to that may help you solve the challenge.
        1. Students will research the different types of pollutants at a specific power plant (Beckjord). They will devise a plan that will use a living organism to remove one of the pollutants from the coal ash ponds.
  2. Identify Alternatives
     1. Use the information gathered during the investigations and research to brainstorm possible solutions. List, describe, and/ or sketch and label at least four plans for your process. When developing your solutions, keep in mind the criteria and constraints. You may use additional paper if needed.
     2. Use the team’s plan to develop the process by doing the necessary research to solve the challenge.
  3. Select Solution
     1. Team members will take turns sharing their ideas for the plan. Together as a team, decide on three possible processes to consider further. After all three processes are developed, complete the Pros and Cons section.
  4. Implement Solution
     1. As a team, choose one particular process to research further. Provide an explanation (claims, evidence and reasoning) of why you choose this particular process. Be sure to include what type of resources your team will use, how the team will document your sources, roles for each team member.
     2. This is where you will support the team’s process. Students will use the provided graphic organizer in the Implement Solution section to aid in collecting data during their research.
        1. Provide an overview of the organism being used
        2. Advantages and disadvantages of its reproductive process
        3. Positive and negative ramifications of introducing the species to the environment
        4. Identify any mutations that may occur.
        5. Provide a safety plan for proper disposal of the organism introduced to the environment.
           + In order to be successful, the organism(s) chosen to clean may or may not have variation in the species. It will depend on the pros and cons of the introduction of the species; for example, if it will be invasive to the environment.
           + They have to justify if the practice of using the organism is an environmentally safe practice.

Provide the positives and negatives of introducing the new organism to the surrounding environment; for example, bio magnification.

Identify typical mutations that occur in the species.

* + - * + Provide a safety plan for proper disposal of the organism they introduced to the environment.

May have to introduce another organism. The organism may or may not have diversity in the species.

Students should note the environment that hinders the organism’s ability to be successful for growth and reproduction; for example, temperature.

May use chemical or physical changes to safely remove the organism from the environment.

* + - 1. They will need to note where they found the information as well.
  1. Communicate
     1. Group Presentation
        1. Students will create a sales pitch to the EPA discussing how their solution will help clean up aftermath of the power plant. They will need to incorporate Google Slides or PPT during the pitch.
        2. The Sales Pitch should include the following components:
           + Company Name and Employees’ Names
           + Pollutant they are removing;
           + Research collected that supports using the organism that will remove the pollutant with appropriate citation;
           + Organism being introduced to the environment;
           + Overview of the organism being introduced;
           + Advantages and Disadvantages of organism’s reproductive process;
           + Positive and negatives ramifications of introducing the organism to the environment;
           + Possible mutations that could occur;
           + Detailed safety plan for proper disposal of the organism they introduced to the environment.
           + Careers in Environmental Remediation

Include a description, salary (range and median), and training/education needed.

* 1. Evaluate
     1. This is where you will support the team’s process. Students will use the provided graphic organizer in the Implement Solution section to aid in collecting data during their research.
        1. Students will practice the sales pitch using the research collected above. The sales pitch should include a presentation with visual representation such as something recorded, display board, Google Slide, Prezi, etc.
        2. Students will use the rubric to help them with the process.
  2. Communicate Solution (Part 1: Reflection)
     1. EDP Graphic Organizer
        1. Communicate Solution: What changes could you make to your design next time? What successes did you have during your challenge? What were some challenges you faced and how did you address them.
  3. Communicate Solution (Part 2: Presentation)
     1. Students will deliver a presentation to the class.
     2. As groups are presenting, have students provide feedback using 1.2.5b Slide Presentation Rubric for each group.
     3. All students will provide feedback to each group as well as the teacher.
        1. It may be easier if each team assigns sections to each team member.
        2. Eliminate enough copies of the rubric for a class set.
        3. With the eliminated rubric and a dry erase marker, students can complete their portion of the rubric for the team presenting.
        4. Once the group is finished presenting, the teams can transfer their section onto the printed rubric.
        5. Each team should receive one completed rubric per team in the class.
  4. Refine
     1. After all students have presented and received feedback. Introduce the refine portion of the EDP.
        1. Groups are responsible for making the suggested revisions to their presentations.
     2. If time permits provide teams with the scenario below. If not move to the next part.
        1. Your company is unable to use the current organism for clean up due to a shortage. The company will need to provide an alternative solution to complete the job.
        2. The new organism being used must clean-up the same toxins as the previous organism.
        3. Be sure to provide the same information that was required before.
        4. Add additional slides to the presentation.
  5. Communicate Solution (Part 3: Revisions of Presentations)
     1. Present again and include the new information as well as any feedback received from your peers.
  6. Evaluate (Final)
     1. Teacher will us 1.2.5b Group Presentation Rubric to evaluate the learning process.
     2. After all presentations, have students complete 1.2.5c Cooperative Learning Self Evaluation & Peer Evaluation Form.
     3. Implement the 1.1.1a Post Assessment

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

* 1.2.5a Engineering Design Process Graphic Organizer
* 1.2.5b Group Presentation Rubrics (Student Feedback prior to revisions)

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Given at the end of the unit:

* Post-Assessment (1.1.1a)
* Group Presentations with rubric (1.2.5b) with Teacher feedback
* Cooperative Learning Self Evaluation & Peer Evaluation Form (1.2.5c)

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  to Activity Template for details. |

* Place students in small heterogeneous groups (3-4) if possible or groups based on their leadership skills.
* Encourage students to ask their peers before asking a teacher.
* Developed graphic organizers for the students to use during research and for presentation information.
* Give students sentence starters for each section.
* Assign sections of the slides to students.
* Create a general slide layout for students. You may insert comments on the slides for students to use as guides.

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

Successes

* Many students were excited about doing the project. One student actually brought in a sample of fly ash also known as coal ash. His father hauls the coal by-product to another company to be used in concrete. I also had coal samples in the room. They were able to make observations of the coal in the closed jar and compare it to the coal ash in another jar. This was a great visual representation for many of them. Students stressed the importance of not opening the lid of the coal ash because of the harmful chemicals inside such as mercury, arsenic, lead, etc.
* The majority of the groups chose to use an organism that reproduced asexually. They were able to determine that less mutations would occur which limits the negative impacts on the environment.
* About half of the students struggled with using the rubric to evaluate their own work. I had to create a checklist that incorporated the same information.
* Students were able to evaluate peer presentations in safe environment. They provided very helpful feedback that lead to the success of their second presentations.
* During the final presentations, each group was recorded. At first students felt uncomfortable about it. I reassured them the purpose was for them to be able to watch their group’s presentation so they could reflect on their performance. This reflection piece will be added at a later date as part of their portfolio work.

Shortcomings

* While doing the research, iBoss blocked must of their websites. Students would have to send me the links they were interested in visiting so I could put in an IT request. Sometimes the webpages would not become available to the students until the next day.
* Most of the reading material about organisms used in bioremediation was above the students’ comprehension. I feel this caused many of them to “give up.”
* Due to time constraints and the lack of available reading material, students were becoming frustrated with the EDP therefore the revision portion below was removed:
  + Your company is unable to use the current organism for cleanup due to a shortage.
  + The company will need to provide an alternative solution to complete the job.
  + The new organism being used must clean-up the same toxins as the previous organism.
  + Be sure to provide the same information that was required before.
* This assignment was more of a research project than an engineering process.
* Modifications needed to be made to 1.2.5a EDP Graphic Organizer. Originally, the Implement Solution portion of the EDP graphic organizer did not leave room for them to create a rough draft for their work. The revised EDP graphic organizer provides a section for them to place all of their information needed to create their presentation. The revised handout also incorporates the rubric used for the presentation. This allows them to evaluate their own work so they can make any necessary revisions to their sales pitch.
* Students jumped right into creating the product instead of collecting all of the necessary information. All groups opened a Google Slide and started putting information into it.
* I wanted students to create a sales pitch using different forms of representations such as a commercial, brochure, Google Slide, Prezi, etc. Every group decided to complete a Google Slide. Very little creativity was observed. After the unit was implemented, students reflected that they did not want to make a Google Slide and thought that is what had to be completed. On many occasions, I would refer them to the criteria and constraints portion of the EDP highlighting the fact they only had to create a sales pitch to the EPA. It was up to them to determine the best method to use.
* The Communication (Reflection) piece was revised as well. Ample space was provided on the handout for the students to reflect. Instead of provided clear explanations, students just wrote bigger. I provided the same amount of space on the revision but also provided lines for them to write on. My hopes are they will write thorough responses the next time.