Grade 8 Learning Experiences: Innovative Irrigation: The Value of Water to Food Security

Experience 3: Design Challenge - build a working model of an irrigation system

Linked Learning Experiences:

Experience 1 Explore the value of water regarding food production across cultures and technologies.

Experience 2 Hands-on activities that demonstrate some factors that affect the flow of fluids.

Experience 3 Design Challenge: Build and test a prototype for an irrigation system based on student research from Experiences (Activities) 1 and 2.

Long Range Plan: Grade 8 Model 1 (February/March)

Overview of learning experiences – why these activities	This set of experiences looks at the importance of water use (irrigation) in crop production. Students research the variety of irrigation methods there are in farming around the world. Using a variety of syringes and tubing of various lengths and gauges, they will then explore the properties of fluids. Finally, they will apply that knowledge to the creation of their own irrigation model. Students will be guided by the engineering design process (Strand A: Engineering design), the concepts of water flow (Strand C: Matter and Energy - Fluids), and the value and importance of water in our environment (Strand E: Earth and Space Science – Water systems). Long Range Plan: Grade 8 Model 1 (February/March)
Prior Knowledge / Prior Skill Set(s)	Background Knowledge and Concepts (Teacher) ● Basic understanding of Systems (inputs, outputs, side effects) ● UN Sustainable goals to link these experiences to real world situations Background Knowledge and Skills (Students) ● Strategies for determining area of an odd shape (or simply calculating the area of rectangles)
Strand A - STEM Investigation and	

Communication Skills	**A1.3** use an engineering design process and associated skills to design, build, and test devices, models, structures, and/or systems (Experience 3) **A1.4** follow established health and safety procedures during science and technology investigations, including wearing appropriate protective equipment and clothing and safely using tools, instruments, and materials (Experience 2, 3) **A1.5** communicate their findings, using science and technology vocabulary and formats that are appropriate for specific audiences and purposes (Experience1, 2, 3) **A3.1** describe practical applications of science and technology concepts in various occupations, including skilled trades, and how these applications address real-world problem (Experience 1,3)
Overview / Big Ideas/Fundamental Concepts	Experience 3 explores Structure and Function. Students are building and modifying a structure to distribute water in a specific way. Each change they make to the structure will have consequences for its function
Learning Goals / Success Criteria	During Experience 3, students will be doing the following: • Following the steps of an Engineering Design Process to create a model to solve a real-world problem of using water sustainably in farming • Working collaboratively with colleagues to complete a series of tasks The main goal is to support students in completing a full cycle of an engineering design process, with a real-world problem concerning sustainable water use practices as a starting point. This series of experiences integrates several of the ten **Ministry of Education Key Topics** introduced in Science and Technology (2022): • **Engineering Design Process:** Provides students with support to plan and build solutions to problems or address needs that connect to the curriculum and the world around them.

	• **Hands-on, Experiential Learning:** Includes hands-on, experiential learning opportunities to support classroom activities that encourage curiosity. • **Emerging Technology:** Ensures that students are aware of exciting and innovative solutions in science and technology that are being implemented today and that may be introduced in the future. • **Contributions to Science and Technology**: Showcases the important contributions made to science and technology from people with diverse lived experiences. Students also explore real-world issues by connecting scientific and technological knowledge systems and perspectives from various cultures, including connecting Indigenous sciences and technologies and Western science and technology. • **Climate Change:** Students will develop the skills and knowledge needed to understand the causes and potential solutions and mitigation strategies related to climate change and other environmental issues, and how they can make the most environmentally responsible decisions possible, given the choices they have. • **Food Literacy:** Skills and knowledge related to food literacy: from students developing an understanding of where food comes from and how it is grown and prepared, to students investigating the importance of biodiversity in agriculture.
Learning Experience(s) **A1.1, A1.3, A1.5**	**A Note about the Engineering Design Process (Design Challenge)** If you are new to teaching science, or to the design process, you are going to find that class time quickly becomes a commodity. Having students think through and plan out their designs takes time and perseverance, but the long-term benefits are great. All the steps in the cycle allow students to see the success of sustained effort. Luckily, you can perform short assessments throughout the process. Additionally, any future design challenges that you present will progress faster as students are now attuned to your expectations and the steps in the cycle. It will be worth it. **Minds On** • As a class, review the completed tables from Experience 1. Ask students questions that will focus their thoughts on the upcoming design challenge:

	○ What were some of the irrigation methods that have been designed or primarily used in countries other than Canada and the United States? ○ On which primary crops were they used? ○ Provide an advantage the method you mentioned has over another method. Provide a drawback ○ Describe some irrigation methods used locally in Ontario ○ Which methods do you think provide the best coverage? Save the most water? Are the most sustainable? ● Have students in partners (or small groups) select one method and brainstorm a few ideas on how it could be improved or easily adapted to benefit another location or crop ● Have some students share their ideas with the class ● As a class, review the summary sheets that students completed when they were exploring factors that affect water flow in Activity 2. Ask students questions that will focus their thoughts on the upcoming design challenge: ○ Which characteristics of the syringes allowed for water to spray the greatest distance? Have the greatest coverage? ○ Which characteristics of the tubing allowed for water to have the greatest coverage? Use the least force? ● In their partners or small groups, have students start to discuss how they might use syringes and tubes to re-create a small-scale model of one of the irrigation methods **Action** ● Project the provided PowerPoint slide show Design Challenge to walk students through the process. A summary of the slide show is provided below. ● **Present the challenge:** ○ Design and build an irrigator that will evenly cover the greatest area of a “field” (2x 12”x18” black piece of construction paper) using only 60 ml of water pumped from a syringe. ● **Present the materials** that will be available: ○ Suggested materials: ▪ bucket ▪ variety of syringe sizes ▪ variety of tubing/straw options

	▪ popsicle sticks ▪ twist ties ▪ pins and screws for drilling holes in tubing ▪ adhesive tape (or glue guns) ▪ Optional: students suggest additional materials ● Introduce an engineering design process diagram (Science and Technology (2022)) and the prompts that accompany each of the steps ● The students have already researched how others have solved the general problem of irrigation. They will be adapting that knowledge to match the design challenge you have presented ● Students will now **Ideate and generate potential solutions**. These can include sketches that replicate known irrigation systems, combine aspects of different systems, or create a completely new system. (Remind them of the criteria – 100 ml of water to cover as much area of 24"x18" black paper field as they can) ● If you find that students are all generating very similar solutions, bring them back to their initial research that had pivots, large, wheeled machines rolling across the field, and workers moving pipes from one place to another. This may expand the options of the task for them. ● If students are working in groups, have each student generate at least one solution and present it to the group. **(1 class)** ● **Select an option and develop a prototype.** The group will then choose a single design, or incorporate aspects of different designs into a final plan. Once in agreement, groups assess how much material they will need and run the plan by the Project Manager (this is you). Most groups will start to build and may need an extra class to complete. **(2 classes)** ● After the design has been built, students will test the prototype on the field. After the total volume of water has been sprayed, one of the group members will use white chalk to trace around the watermarks. This will allow them to calculate the surface area that their irrigator covered at a later time. **(1 class)** ● All student tests need not be conducted in the same period. ● Taking a video of the test is recommended – this will allow the students to be able to rewatch and analyze where the device fails. It also provides students with a basis for their presentation at the end of the challenge. It will illustrate points of failure and give students an opportunity to address the improvements they made to the prototype.

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Students will then evaluate the results and make plans to revise the prototype (see Appendix A: Design Challenge: Data Collection). (1 class)
Students make changes to the design and rebuild the prototype according to these specifications. (1 class)
Optional step for students who have completed the testing and rebuild process early: Students can test the final build (recording the final test as well) and evaluate it in the same way.

Consolidation

Students will then communicate the solution that they found to the irrigation problem by presenting their findings to the class by showing the testing video, explaining the problems they noticed, and how those issues lead to the modifications in their revised prototype.
If they tested the revised prototype, they would include the first and second test videos while referencing the changes that they made to their design, the reasons and concepts behind why they made these changes, and the quantitative results of these changes. (1 class)
While observing the presentations, students will record one of the ideas that they liked about each of the presented irrigators and something that they would change in the next design. They will include a reason why they would make that change. (1 class)

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<td>Science and Technology Expectations</td>
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Overall & Specific Expectations from the Science and Technology curriculum

Strand C: Matter and Energy (Fluids)
Overall Expectation
C1. Relating Science and Technology to Our Changing World: analyse uses of various technologies that rely on the properties of fluids, and assess the impact of these technologies on society and the environment (Experiences 1,2,3).
Overall expectation
C2. Exploring and Understanding Concepts demonstrate an understanding of basic fluid mechanics, including the properties and uses of fluids (Experiences 2, 3)
C2.6 Explain in qualitative terms the relationship between pressure, volume, and temperature when a liquid or a gas is compressed or heated (Experience
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	2 addresses the relationship of pressure and volume of water when it is compressed, Experience 3 applies this concept to the design challenge) **C2.7** describe how forces are transferred in all directions in fluids, including using Pascal's law to quantify the transfer of forces in fluids (Experience 2, 3) **C2.8** describe factors that affect the flow of fluids (Experiences 1, 2, 3) **Strand D: Structures and Mechanisms (Systems in Action)** **Overall Expectation** **D2**. Exploring and Understanding Concepts demonstrate an understanding of different types of systems and the factors that contribute to their safe and efficient operation (Experience 1, 2, 3) **D2.2** describe the purpose, inputs, and outputs of various systems, including systems related to food processing (Experience 1,3) **D2.3** identify the various processes and components of a system that allow it to perform its function efficiently and safely (Experience 3) **D2.7** identify ways in which energy can dissipate from mechanical systems, and describe technological innovations that make these systems more efficient (Experience 3) **D2.9** describe technological innovations involving mechanical systems that have increased productivity in various industries (Experience 1, 3) **D2.10** identify social factors that influence the evolution of a system (Experience 3) **Strand E: Earth and Space Systems (Water Systems)** **Overall Expectation** **E1.** Relating Science and Technology to Our Changing World assess the impact of human activities and technologies on the sustainability of water resources (Experience 1, 3) **E1.1** assess the social and environmental impact of the scarcity of fresh water, and propose a plan of action to help address fresh water sustainability issues (Experience 1, 3) **E1.3** assess the impact of scientific discoveries and technological innovations on local and global water systems (Experience 1, 3)
Science and Technology Vocabulary	Irrigation system – inputs, outputs, side effects. Drought, Area of a rectangle, independent variable, dependent variable, fixed variable, prototype.

Equipment and Materials	Bucket for water variety of syringe sizes (5ml, 10ml, 20ml, 30ml, 60ml) variety of tubing/straw options popsicle sticks twist ties pins and screws for drilling holes in tubing adhesive tape (or glue guns) online-enabled devices for research clipboards
Timeline and Preparation	**Experience 3** **Approximately 6-7 class periods** ● Reviewing the concepts and ideas from Activities 1 and 2 and introducing the challenge and generating potential solutions (1 class) ● Selecting an option and developing a prototype (1-2 classes) ● Testing the prototype, reviewing the data (1 class) ● Modifying the prototype and preparing a short explanation to accompany the prototype (1 class) ● Optional step: Testing the modified prototype and comparing the data from the first and second test (1 class) ● Presenting the prototype to the class with an explanation of how it works. (1 class)
Safety Considerations	Safety considerations include the following: ● Students wear safety goggles when using the syringes filled with water ● Demonstrate proper use of syringes for students ● Demonstrate using pins to poke holes in straws (e.g., pointing the pin away from you and keep fingers clear of the path of the pin on the other side of the straw). Refer to these safety resources: ● Safety in Elementary Science and Technology (STAO) ● Safe Activity Foundations in Education Document (SAFEdoc) Science and Technology, Grades 1-8 (OCTE) ● Ontario Curriculum Program Planning – Health and Safety

Opportunities For Assessment	Below are suggestions for opportunities for assessment during Experience 3. Inside the ellipses is the section of the Achievement Chart from Science And Technology (2022) that corresponds. Assessment OF learning ● Use the provided Design Challenge Checklist (see Appendix B: Design Challenge Checklist) to assess how groups are progressing through the steps of the Engineering design process. ● Use the provided Design Challenge Data Collection sheet (see Appendix A: Design Challenge: Data Collection) to assess how they are recording the results of tests and calculating the area of water coverage. ● Assess the final presentation (and explanation of their testing video). Have they addressed weaknesses in the original design? How have they corrected them in the final prototype? Why do they think these changes will be successful? ● Have students reflect on the entire process of the engineering design process and assess their own work at each step. Have them pick a step where (and how) they will make an improvement in their process during the next design challenge (e.g., if they had difficulty making an initial drawing, or were challenged by group dynamics during the building phase). This will help to inform your evaluation of learning skills for these students. ● Use the provided Design Challenge Rubric (see Appendix C: Design Challenge Rubric) to assess each of the sections of the achievement chart from Science and Technology (2022).
Instructional Strategies and Adaptability	● As with the stations in Experience 2, it may be advantageous to assign roles to the group members to ensure participation by all members. ● Consider selecting tailored roles for students who have certain expectations to achieve on their IEP with regard to science, or ELL students who may feel more comfortable with a concrete role, as opposed to one that requires a great deal of oral information processing.
Additional Supporting Resources	● Drought and Agriculture - Predict, Plan and Prepare: Stop Drought Becoming Famine - YouTube ● Home | Sustainable Development (un.org)

Cross-Curricular Opportunities	**Mathematics**
	● Measurement (compare, estimate and determine measurements in various contexts)
	
	Language
	● Oral Communication
	    ○ Listen in order to understand and respond appropriately in a variety of situations and a variety of purposes
	    ○ Use speaking skills and strategies appropriately to communicate with different audiences for a variety of purposes

Future Opportunities / Next Steps	● If students progress quickly with the engineering design process, adding a second round of testing and modification of the prototype will add depth to the experience. Students who do this will be able to compare data between the two tests, see their improvement of field surface coverage, and observe new problems that arise. ● Alternatively, students could explore how their irrigator performs if the topography of the field is more complex. In some parts of Southern Ontario (e.g., the HWY 400 corridor) fields are not flat, but are rolling hills. Place some blocks or upside-down cups under the field to produce contours. Test the irrigator in this capacity. What modifications might students have to make in this new context?

Appendix A: Design Challenge: Data Collection

Design Challenge: Data Collection

Before the Testing: Draw on this page how you plan to deliver the 100 mls of water to the field. Will it all be from one point on the field, or multiple points using different volumes? Will a machine help the piping to move, or will it be stationary?

After the Testing: How will you determine the area of the field your test has covered? A general rectangular area, or a more exact method? If you are using rectangles to help you determine the area, fill in the table below:

Rectangle	Length	Width	Area
1			
2			
3			
4			
5			

Total area calculated:

Reflect: Look at your planned irrigation and your results. Do they match? What might you need to change about your process that will allow you to get greater coverage?

Appendix B: Design Challenge Checklist

Design Challenge Checklist: Innovative Irrigation

Group Name: ______________________

Group Members: ___________________

Step of the Process	Notes and Comments	Date
Research and understand a Problem		
Ideate and generate potential solutions		
Select an option and develop a prototype		
Test the prototype		
Evaluate and revise the prototype		
Communicate the solution		

Appendix C: Design Challenge Rubric

Design Challenge Assessment Rubric

	Level 1	Level 2	Level 3	Level 4
Knowledge and Understanding: uses terminology from the unit of study	Demonstrates limited knowledge of content	Demonstrates some knowledge of content	**Demonstrates considerable knowledge of content**	Demonstrates thorough knowledge of content
Thinking and Investigation: gathers and records data from the testing of the prototype	Uses processing skills and strategies with limited effectiveness	Uses processing skills and strategies with some effectiveness	**Uses processing skills and strategies with considerable effectiveness**	Uses processing skills and strategies with a high degree of effectiveness
Thinking and Investigation: analyzes, interprets and acts on the data from the prototype	Uses critical/creative thinking processes, skills and strategies with limited effectiveness	Uses critical/creative thinking processes, skills and strategies with some effectiveness	**Uses critical/creative thinking processes, skills and strategies with considerable effectiveness**	Uses critical/creative thinking processes, skills and strategies with a high degree of effectiveness
Communication: presents the prototype, results of testing and interpretations of the investigation to peers	Expresses and organizes ideas and information with limited effectiveness	Expresses and organizes ideas and information with some effectiveness	**Expresses and organizes ideas and information with considerable effectiveness**	Expresses and organizes ideas and information with a high degree of effectiveness
Application: the final product proposes a practical solution to a problem in our changing world	Proposes courses of practical action with limited effectiveness	Proposes courses of practical action with some effectiveness	**Proposes courses of practical action with considerable effectiveness**	Proposes courses of practical action with a high degree of effectiveness