CASTLE COMPLEX EDP PHASE 2 PROJECT (2018-2021)

UbD STEM UNIT PLAN TEMPLATE (adapted from ONR Engineering Success in STEM Project)

Teachers' Names: Tara Seto Māpuana Leong	**School:** Kāneʻohe Elementary School	**Grade Level:** 4
Content Area: Science	**Course Name:** N/A	**Period:** N/A
Unit Title: Designing a Water Filter - For specific information refer to the EiE Boston Engineering Kit (resource available on the STEM Pre-Academy website)	**Approximate Time Frame:** Spring 2020	

Essential Vocabulary:
- *Ask*: to define the problem and identify the solution requirements
- *Constraint:* a limitation or restriction
- *Contaminated:* having been made impure by exposure to or addition of a poisonous or polluting substance
- *Create*: to follow your plan, build your solution and test it against your criteria
- *Criteria:* a principle or standard by which something may be judged or decided
- *Data:* facts and statistics collected together for reference or analysis
- *Imagine*: to come up with possible solutions and determine which is the best one using available materials
- *Improve*: to revisit the problem and the plan, and determine what can be improved
- *Plan*: to develop a plan via diagrams and labels, and gather the materials
- *Requirement:* a necessary condition

STAGE 1: DESIRED RESULTS

NGSS Standard(s)
- MS-ESS3-1* Earth and Human Activity (*find appropriate NGSS for elementary (GR4)
- 3-5-ETS1-1 Engineering Design
- 3-5-ETS1-2 Engineering Design
- 3-5-ETS1-3 Engineering Design
- 5-ESS3-1 Earth and Human Activity

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

Dimension	**Name and NGSS code/citation**	**Matching student task or question directly from the activity**
Science and Engineering Practices (SEPs)	**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. **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	Students will learn more about and define the problem of water pollution and identify the solution requirements, specifically the four criteria of cost, removal of color and particles and efficiency (time). Students will imagine multiple solutions via diagrams and labels in order to discuss with group members and choose the most viable solution, given the criteria. Students will plan, build and test their chosen design. Later, they will

	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. **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. **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.	reflect, analyze data, and improve their design.
Disciplinary Core Ideas (DCIs)	**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. **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. ● 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. ● Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. **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. **ESS3.A: Natural Resources** ● Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human	Students should understand: ● a good design will meet all of the criteria for solving a problem (in this case, speedy filtration, removal of particles and color, and low cost) to some degree. ● sometimes increasing the performance of a design on some criteria (e.g., making cleaner, clearer water) will decrease its performance on another criteria (e.g., cost).

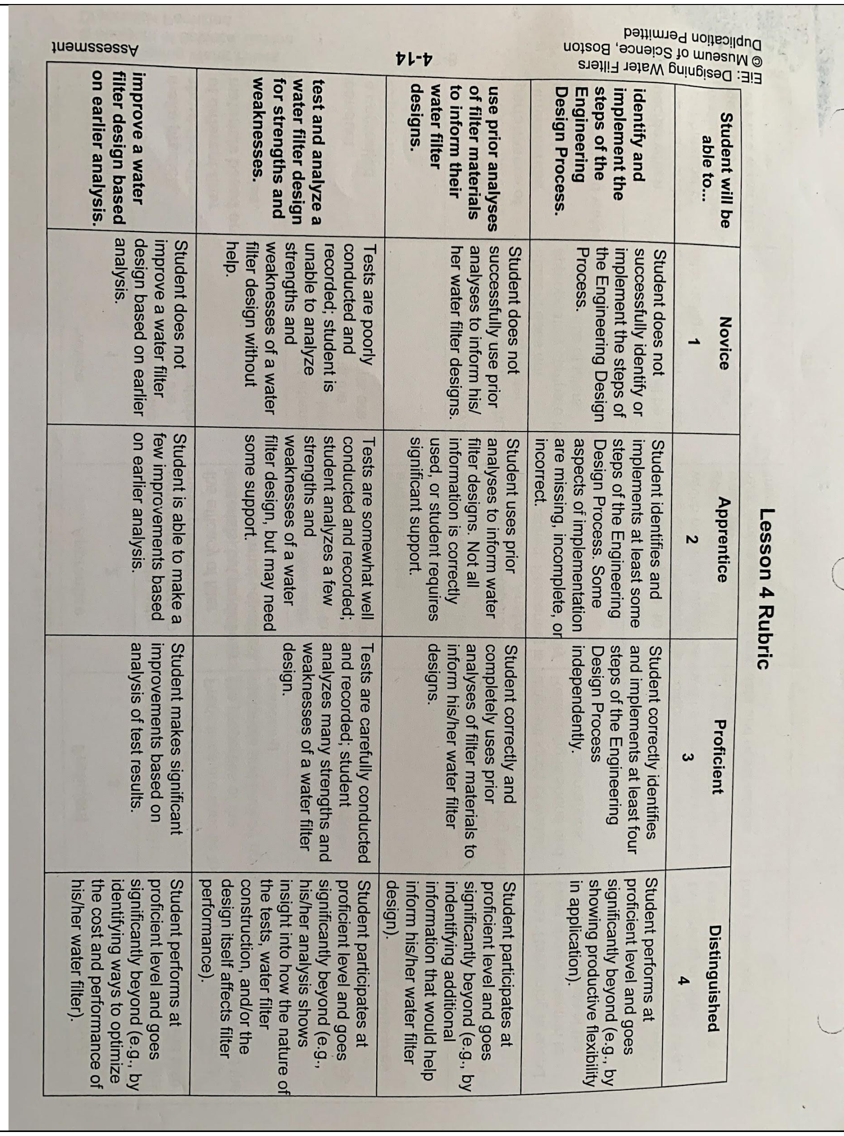
	lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. **ESS3.C: Human Impacts on Earth Systems** ● Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.	
Crosscutting Concepts (CCCs)	**Cause and Effect** ● Cause and effect relationships may be used to predict phenomena in natural or designed systems. **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. ● People's needs and wants change over time, as do their demands for new and improved technologies. ● Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. **Systems and System Models** ● A system can be described in terms of its components and their interactions. **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.	Students will read Saving *Salila's Turtle*. Students will also visit Waikalua Loko Iʻa and learn more about water quality, including human impact.

Learning Goal (Student Learning Objectives): (Skills, content knowledge and understandings, values, etc.) *Students will be able to…*	Students will be able to… ● use EDP to design a water filter to clean non-toxic contaminated water. ● *ask* about the problem, *imagine* different solutions, *plan*, *create*, test their water filter designs, and *improve* their designs based on test results.
Essential Question(s):	How can we use our knowledge of how different filter materials work, our creativity, and EDP to design and improve a water filter that cleans contaminated mystery water?
Enduring Understandings (Big Ideas): (Broad understandings that are not tied to place, time, specific people, etc.)	Students will learn that: ● engineers use a series of steps, called the Engineering Design Process, to design solutions to problems. ● a good design will meet all of the criteria for solving a problem (in this case, speedy filtration, removal of particles and color, and low cost) to some degree. ● sometimes increasing the performance of a design on some criteria (e.g., making cleaner, clearer water) will decrease its performance on another criteria (e.g., cost).
Other Standards/Benchmarks: Common Core Literacy Standards/Mathematical Standards	● **4.SL.1** - Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly.

C3 Framework for Social Studies Fine Arts Standards	● **4.W.7** - Conduct short research projects that build knowledge through investigation of different aspects of a topic. ● **4.W.8** - Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. ● **CCSS.ELA-LITERACY.RI.4.7** - Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.

STAGE 2: ASSESSMENT EVIDENCE

Summative Assessment/ Performance Task	How do you and other living things use water? Where does your water come from? How do you know that your water is clean and safe to drink? What do you think will happen if you drink dirty water? What do you know about Hawai‘i’s natural water filtration? The water we drink is clean and safe thanks to the environmental engineers who design and manage our water supply and water treatment systems. Students will work in groups of three or four to design a water filter with various materials. They will plan their water filter designs and calculate the cost of their designs. They will create and test their filters, scoring them on the established criteria. Students will improve their water filter designs based on the results of testing and their final score.

Rubric(s) for Summative Assessment/Performance Task: (Refer to EiE Boston Engineering Kit for Rubric)	
Formative Assessments: (Refer to EiE Boston Engineering Kit for Rubric)	Formative assessments include whole group and small group discussion participation, visual observations and reflection questions in the Engineering Notebook. Also, prior to designing their water filters, students explore some of the filter materials (screen, paper filter, sand and gravel) individually to determine their usefulness. Below is the rubric for that activity.

Lesson 4 Rubric

Student will be able to...	Novice 1	Apprentice 2	Proficient 3	Distinguished 4
identify and implement the steps of the Engineering Design Process.	Student does not successfully identify or implement the steps of the Engineering Design Process.	Student identifies and implements at least some steps of the Engineering Design Process. Some aspects of implementation are missing, incomplete, or incorrect.	Student correctly identifies and implements at least four steps of the Engineering Design Process independently.	Student performs at proficient level and goes significantly beyond (e.g., by showing productive flexibility in application).
use prior analyses of filter materials to inform their water filter designs.	Student does not successfully use prior analyses to inform his/her water filter designs.	Student uses prior analyses to inform water filter designs. Not all information is correctly used, or student requires significant support.	Student correctly and completely uses prior analyses of filter materials to inform his/her water filter designs.	Student participates at proficient level and goes significantly beyond (e.g., by indentifying additional information that would help inform his/her water filter design).
test and analyze a water filter design for strengths and weaknesses.	Tests are poorly conducted and recorded; student is unable to analyze strengths and weaknesses of a water filter design without help.	Tests are somewhat well conducted and recorded; student analyzes a few strengths and weaknesses of a water filter design, but may need some support.	Tests are carefully conducted and recorded; student analyzes many strengths and weaknesses of a water filter design.	Student participates at proficient level and goes significantly beyond (e.g., his/her analysis shows insight into how the nature of the tests, water filter construction, and/or the design itself affects filter performance).
improve a water filter design based on earlier analysis.	Student does not improve a water filter design based on earlier analysis.	Student is able to make a few improvements based on earlier analysis.	Student makes significant improvements based on analysis of test results.	Student performs at proficient level and goes significantly beyond (e.g., by identifying ways to optimize the cost and performance of his/her water filter).

EiE: Designing Water Filters
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Assessment

Lesson 3 Rubric

Student will be able to...	Novice 1	Apprentice 2	Proficient 3	Distinguished 4
make predictions about the efficacy of different filter materials based on their properties.	Student does not make predictions about the efficacy of filter materials.	Student is able, with significant support, to make predictions about the efficacy of filter materials, but predictions are somewhat unjustified.	Student is able to make predictions about the efficacy of filter materials. Predictions are specific to the properties of the materials and backed up by reasoning.	Student makes predictions at proficient level and also records insights and connections to the world beyond the activity and the classroom.
conduct a controlled experiment.	Student does not attend to procedure and note-taking when conducting the experiment. Efforts are haphazard.	Student is able, with significant support, to conduct the experiment. Student makes efforts to keep procedure consistent and takes notes.	Student successfully conducts the experiment; procedure is consistent and notes are complete.	Student performs at proficient level, and in addition is able to discuss which variables are controlled or contributes other insights.
observe, analyze, and compare the performance of different filter materials when used to filter contaminated water	Student does not analyze the properties of filter materials in terms of their ability to clean water. Student does not appropriately compare the performance of filters.	Student needs significant support to analyze and compare the properties of filter materials. Analysis is not justified. Reasoning is weak and not necessarily linked to observations.	Student is able to analyze the properties of filter materials, comparing them in terms of success filtering different kinds of water. Reasoning is sound and linked to observations.	Student makes an attempt to explain the analysis in terms of his or her experience along with class data. Reasoning is sound and shows attention to multiple aspects of the experiment.
decide which materials and/or combination of materials will be good choices to use in a water filter design.	Student is not able to decide which materials will be good choices to use in a water filter design.	Student is able, with significant support, to make decisions about which materials would be good choices to use in a water filter design, but reasoning is weak and not linked to data or	Student is able to decide which materials and/or combination of materials will be good choices to use in a water filter design. Reasoning is based on data and observations.	Student performs at proficient level and goes significantly beyond, (e.g., by thinking of other materials that would be good choices, based on their properties).

EiE: Designing Water Filters

Engineering Notebook (Refer to EiE Boston Engineering Kit for Rubric)	(Refer to EiE Boston Engineering Kit for hard copies of the Engineering Notebook.)

STAGE 3: LEARNING PLAN:

GR4 Designing a Water Filter EDP Unit Plan (2019-20, Kāneʻohe Elementary School)

The daily activities should address all aspects of the EDP, plus the communication/sharing process:**

Problem Statement (Scenario)
Ask: Need Identification, Problem Statement, Client(s), Specifications
Imagine: Research, Brainstorm Solutions
Plan: Pugh Chart, Gantt Chart, Materials, Equipment, Procedures
Create: Prototype/Model, Test
Improve: Reflect, Improve/Modify, Test

ASK (give a time frame for each activity)

During our first lesson, we begin with a discussion about water, asking students the following questions: How do you and other living things use water? Where does your water come from? How do you know that your water is clean and safe to drink? What do you think will happen if you drink dirty water? What do you know about Hawaiʻi's natural water filtration? We also review their learnings from their January 2020 Kauaʻi sustainability trip, including the Waiahi Surface Water Treatment Plant. Then, we read a book from the Boston Museum of Science Kit, *Saving Salila's Turtle.* Students then blend this story with their prior knowledge to think about the problem of water pollution and some possible solutions.

Next, we review vocabulary and work on their Engineering Notebooks by exploring our goal (to design a water filter that can clean contaminated "Mystery Water"). We determine our criteria (1) the cost of our water filter design, 2) how well our water filters remove color from contaminated water, 3) how well our filters remove particles from contaminated water, and 4) how quickly water moves through our filter. Students also predict and justify which materials will work well to clean the mystery water.

IMAGINE

To begin, we explore some of the filter materials (screen, paper filter, sand and gravel) individually to determine their usefulness. We divide the task by having some groups test the screen, some test the paper filter, and some test the sand and gravel. Groups also test different types of contaminated water-- tea water, soil water, and cornstarch water. We take data on whether each filter removes particles, color and how long it takes for the water to filter. Then, we compile our class data so everyone has complete data about each type of filter material. Students can then use this data to imagine their filter design.

Next, the students individually brainstorm at least four different designs to filter contaminated mystery water. They draw diagrams of their designs, including labels and quantities of each filter material they would like to use. Then, as a group, students take turns sharing their brainstormed ideas and choose one (or a combination of multiple ideas) to build. In discussions, students explain why they think certain aspects of their designs are best. They should refer to the four criteria of cost, removal of color and particles and efficiency (time).

PLAN

Students then draw a diagram of the final water filter design that they chose as a group. They must label and add quantities of each filter material they are using. Students must also fill out a table that includes the filter material, quantity, cost per unit and total cost. Then, they have their cost score for their water filter design. Using their filter design diagram and cost table, they procure necessary materials.

CREATE

As a group, students build their water filter prototype and test it. They fill out a score chart rating their filter according to cost, removal of color and particles, and efficiency (time).

IMPROVE

Students reflect upon their testing experience. They think about and discuss which criteria they will try to improve, and how they will try to improve it. Then, they redesign their water filter, procure new materials, and rebuild a new prototype. Students then test their new prototypes. They can repeat the improve step as many times as possible.

COMMUNICATE**

At our STEM Hōʻike on March 11, 2020, students presented the problem and steps they took to design solutions. They shared a video about the entire process of exploring filter materials, imagining, planning, creating and testing their prototypes. Then, students broke out into individual stations and invited visitors to view their Engineering Notebooks and water filters in action. Unfortunately, students did not get to the improve stage.

Materials, Equipment and Resources Needed to Implement Unit

- tea leaves to make tea water and mystery water
- potting soil to make soil water and mystery water
- cornstarch to make cornstarch water and mystery water
- 6 2-liter plastic bottles
- 6 size 4 rubber stoppers with drip hole
- 6 pans/basins
- 36 plastic cups
- 5 1-liter plastic bottles with caps
- screen
- coffee filters
- uncolored aquarium gravel
- art sand
- cotton balls
- cheesecloth
- water
- timer
- tape