Design STEMS²

Lesson 1: mālama ʻāina - to care for the earth
Lesson 2: kuleana - responsibility; laulima - cooperation, many hands working together
Lesson 3: ʻike - knowledge
Lesson 4: lōkahi - unity, balance, harmony
Lesson 5: review
Lesson 6: aloha - empathize
Lesson 7: wehewehe - define
Lesson 8: puaʻi manaʻo - ideate
Lesson 9: ana - prototype
Lesson 10: hōʻike - test; review

Lesson 1 Title: Water – Everybody Needs it! Introduction to Watersheds
Course: **Environmental Science**
Teacher(s): **Lisa Mason**
Duration: **5 days**

Lesson Objectives:

- Classify the forms, and percent composition, which freshwater is found on Earth.
- Explain the importance and uses of Freshwater for living organisms and human development.
- Identify the above-ground and below-ground components of a watershed and aquifer system.
- Analyze changes (human and natural) in Hawaiian watershed over time and how these changes affect the watershed and ecosystems.
- Explain that freshwater is a renewable, yet limited resource, and must be used sustainably.
- Can use the model to explain how water and pollutants move across the landscape.

Content Standards:

- HS-ESS2-5. Plan and investigate the properties of water and its effects on Earth materials and surface processes.
- HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- D2.Geo.4.9-12. Analyze relationships and interactions within and between human and physical systems to explain reciprocal influences that occur among them.
- RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) to address a question or solve a problem.

Lesson Launch Notes:	Lesson Closure Notes:
1. What is an ʻahupuaʻa? 2. Do you live in a watershed? Students were assigned to watch the Hawaii DLNR Rain Follows the Forest Video on YouTube and took a short quiz online. Review answers to online quiz. Video: https://youtu.be/N0oHdMPYSq8 (29 min) mālama ʻāina - to care for the earth laulima - cooperation, many hands working together	Students will participate in an informal group discussion to answer the following questions: Guiding Questions: • What is a watershed? • What are current threats to the above-ground and below-ground components of [the Hilo and Waiakea] watersheds and aquifers? **How can scientific, traditional, and community-based approaches be used to protect watersheds, conserve**

	freshwater resources, and help to design innovative solutions for sustainability in Hawai'i?

Lesson Tasks, Problems, and Activities (attach resource sheets):

Before the Lesson - Assign the DLNR Rain Follows the Forest movie for students to watch before the first lesson. Post an online quiz, or give quiz as bell work for the first 5 min. of class. Setup watershed model stations with materials.

Engage (10 min)

- Define mālama ʻāina. What does that mean to you? What does that mean for us in science class?
  - Design STEMS2 mindset: embrace multiple lenses by engaging in authentic, hands-on investigation, problem solving and community service.
- Watch Video: Kumukahi Wai http://www.kumukahi.org/units/ka_honua/ao/wai
- Have a glass of water ready. Ask students where the water came from. Determine how many students are on county water, or catchment.
  - Record answers on the board/notebook for later comparison.
- Explain that our locally sourced freshwater is collected in an area of land called a watershed.
  - Do you live in a watershed?
  - Poll students if they are familiar with the term ʻahupua'a. What is an ʻahupua'a? Define using classroom poster or photo.

Explore - Watershed model activity (1.5 classes)

- Pass out lesson worksheet.
- Review the major components of the water cycle (from biogeochemical unit).
- Students will build a physical model of a watershed that contains the following features: mountain, topographical contours of ridges and valleys, drainage divide, valley floor/ floodplain, base/coastline.
  - Using wadded newspaper, secured with masking tape, students will create features of a natural landscape within a large plastic bin. A plastic sheet from a cut up garbage bag (white) will serve as the surface lining of the watershed. The watershed can be tilted or elevated by using a block or textbook to raise one end of the bin. Show students maps of Hawai'i Island, Mauna Kea, Mauna Loa, Waipiʻo Valley, or ʻahupua'a of Waiākea to help them visualize a realistic shape for their watershed model.
  - Draw a topographical map of a hypothetical watershed. Explain to students how to draw a topographical map using contour lines on a piece of graph paper. Each contour line will represent 100m of elevation gain. Lines drawn closer together represent peaks and lines wider apart represent gradual sloping flatter areas.
  - Using a spray bottle containing water and 1-2 drops of blue food coloring, spray "rain" to the top of the model at the highest peak, where the headwaters begin.
  - Draw the path which water flows and pools in the model using a blue colored pencil.
  - Record the headwaters, streams, rivers, lakes, drainage divide, valley floor, and delta of the river if these features are apparent.
- Discuss major types of land uses for this model: rural/urban development, industrial, forest, agriculture, ranching, wetland. Record on watershed map where each land use type is located.
- Using the model, have students assign different land usages based and mark these areas on their maps. They can color code these or use different colored permanent markers to draw the regions directly on their models. The more visual the model can become, the better!
  - Apply small squares of green felt across the model to represent areas of forest.
  - Add up to ½ teaspoon of soil under the felt and also a small amount of soil to a nearby exposed area.

  - Make it rain again and record observations.
  - Add the "agricultural waste" to designated ranch lands, "fertilizers" to croplands. Make it rain and record observations.
  - Add "oil pollution" to residential areas" Make it rain and record observations.
    - Blue water = clean, unpolluted water
    - Yellow turmeric powder = animal waste
    - Green Epsom salts = fertilizer
    - Black soy sauce = residential oil spill
- Add more rain to the watershed to enhance the effects of runoff on water quality in the model. Record areas of contamination and path which pollutant travelled onto map. Make observations in notebook.
- Students should record any questions they still have about their watershed model.

Explain (1 class or flipped lecture)
- Focus on the path that each pollutant travels across the watershed system. Notice sedimentation at the coastline.
- Encourage students to explain how pollutants can contaminate water sources far away from the point-source. Students should also identify the challenge of remediation for non-point source cases (i.e. motor oil runoff).
- Ask students to think about possible sources of underground water contamination (i.e. septic tanks, fuel tanks, infiltration of surface pollutants).
- Students should be able to see the connection between forested areas and the prevention of soil erosion. Sedimentation can harm coral reefs and other types of coastal ecosystems (e.g. estuaries). Ask students to think about the areas that they recreate. How would they know they are swimming in clean, healthy water?
- PPT: Chpt. 15 Freshwater Resources, Major Land Uses, Watershed Partnerships

Elaborate (1 class)
- Handout or display USGS maps of streams and watershed zones on Hawai'i Island.
  - Current stream flow conditions: https://hi.water.usgs.gov/
  - https://nwis.waterdata.usgs.gov/hi/nwis/current/?type=flow&group_key=county_cd
- Display Google Earth images or ArcGIS map of Hawai'i Island showing satellite imagery of East Hawai'i.
- Ask students why urban development in Hawai'i is mostly coastal. What resources or services are available at the coastlines versus inland? How does the topography of the land dictate how land is used?
- Compare Hawaii Island to watershed maps of O'ahu (Ko'olau Range- Mānoa Valley- Ala Wai). Why is it easier to see the drainage divides on the O'ahu map versus the Hawai'i island map? Where is it important to check water quality within the watershed? What factors affect a city's water supply?

Evaluate (1 day)
- Complete reflection questions.
- Lesson quiz (online).
- Watershed model map labeled and colored.

Evidence of Success:
- Students can build and explain features of their watershed model using accurate and precise terminology.
- Students can answer questions related to their particular model and elaborate on responses from their peers.
- Students can create watershed maps that clearly represent all physical features of their models neatly and accurately.
- Students can interpret satellite data to enhance their own understand of Hawaii's geography.
- Students can explain the relationship between watershed boundaries and cultural/political boundaries (i.e. 'ahupua'a system)

- Answer analysis and reflection questions related to the activities.
- Pass online quiz.

Notes and Nuances:

- Vocabulary: STEMS², mālama ʻāina, ahupuaʻa, watershed, point source pollution, nonpoint source pollution, eutrophication
- Optional: Students can graph the monthly precipitation and monthly streamflow for an area (Hawai'i Island) if data is available.
- Extension topics: salt-water intrusion, over-extraction of groundwater from wells reduces stream levels and depletes aquifers, urban sprawl

Materials/Resources:

Watershed model supplies

- Plastic bins (28.5 x 18 x 6.3 inches) - 1 per team
- Newspaper, masking tape
- Trash bags (white 13 gal.) cute into sheets
- Spray bottles, food coloring
- Permanent colored markers
- Green felt
- Assorted "pollutants" (turmeric powder, soy sauce, Epson salts w/ food coloring, soil)
- Graph paper, pencils

Google Earth
USGS stream data
Land use map for Hawai'i island
Understanding Watershed reflection questions
Watershed Pre-quiz
Watershed Post-quiz
DLNR Rain Follows the Forest video

Homework: *Exactly what follow-up homework tasks, problems, and/or exercises will be assigned upon the completion of the lesson?*

- Watershed Pre-quiz and Post-quiz
- Understanding Watersheds reflection questions

Lesson Reflections:
Did I give an example of a completed watershed model before students created their own?
Did I post online materials early enough to allow students time to complete?
Did I ensure that all materials were properly setup in advance, downloaded, or colored copies were provided?
Did I allow enough time in class for students to speak with each other and ask questions?
How can I build stronger connections to the standards?
Was online data recent? How can I enhance the data interpretation portion of this lesson?
Do students have a deeper understanding of our island's geology, hydrology, geography, and/or cultural connection?

Lesson 2 Title: Introduction to Honokea at Waiuli (Learning Journey 1)
Course: Environmental Science
Teacher(s): Lisa Mason
Duration: 5 days

Lesson Objectives:
- Identify the various sections of land divisions used in Hawaiian culture.
- Define loko i'a as a method of Hawaiian aquaculture.
- Engage in culturally appropriate protocol upon arrival to field site.
- Describe Waiuli according to its place-specific history and moʻolelo.
- Identify the various ways in which Waiuli is used by various community groups and the impacts these groups have in the area.
- Assess different sources of information to infer meaning of Hawaiian language terms related to loko iʻa.
- Compare different kinds of loko iʻa systems.
- Analyze the components of a loko iʻa system.
- Summarize the key features of Honokea by creating a detailed map of the area.
- Perform halihali, staggered rock passing, and set rocks to build a properly formed section of the kuapā (rock wall) at the loko iʻa.
- Analyze the relationship which modern society has with loko iʻa compared to ancient society.

Standards:
NGSS
- HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

C3
- D1.5.9-12. Determine the kinds of sources that will be helpful in answering compelling and supporting questions, taking into consideration multiple points of view represented in the sources, the types of sources available, and the potential uses of the sources.
- D4.6.9-12. Use disciplinary and interdisciplinary lenses to understand the characteristics and causes of local, regional, and global problems; instances of such problems in multiple contexts; and challenges and opportunities faced by those trying to address these problems over time and place.
- D2.Geo.3.9-12. Use geographic data to analyze variations in the spatial patterns of cultural and environmental characteristics at multiple scales.
- D2.Geo.4.9-12. Analyze relationships and interactions within and between human and physical systems to explain reciprocal influences that occur among them.
- D2.Geo.6.9-12. Evaluate the impact of human settlement activities on the environmental and cultural characteristics of specific places and regions.

Common Core Math/ LA
- WHST.9-10.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

Lesson Launch Notes:	**Lesson Closure Notes:** Exit Pass

● Reminder of field days and what to bring, answer questions regarding our upcoming work at Waiuli and with Hui Ho'oleimaluo	1. How may loko i'a affect local food production for a community? 2. In what ways do loko i'a serve as ancient evidence of engineering innovation in Hawai'i? **How can scientific, traditional, and community-based approaches be used to protect watersheds, conserve freshwater resources, and help to design innovative solutions for sustainability in Hawai'i?**

Lesson Tasks, Problems, and Activities (attach resource sheets):

Pre-lesson – (20 min)

- Define kuleana and laulima. What do these words mean to you? What do they mean for our science class?
  - Design STEMS2 mindset: empathize through the 3Ps (time period, place, people) via a place-based, community-based partnership.
- Introduction to Paheahea Loko oli, practice
- Watch Video: Kumukahi http://www.kumukahi.org/units/ka_honua/onaepuni/ahupuaa
  - Review ahupua'a and Hawaiian land divisions
  - Where is Waiuli?
- What's special about Waiuli (Richardson's Beach Park)?
  - Briefly "quiz" students on their prior knowledge of Waiuli and have students make a list of the features of Waiuli that they can recall from memory of going there in the past.
  - If they were fish, where could they live in the area of Waiuli?
  - What types of aquatic ecosystems are there are Waiuli?
  - How do people use Waiuli?

Learning Journey Plan
Engage – (field, 40 min)

- Arrive at Waiuli early morning (8:00am)
- Introduction to Hui Hoʻoleimaluo team and Honokea
- Practice of Paheahea Loko oli
  - Pass out reading packet
- Kilo 1
  - Pass out worksheets with clipboards to students. Allow about 15 min for completion of their kilo individually and quietly. Recommend quiet spaces for observations.

Explore – (field, 1.5 hours)

- Pass out Learning Journey 1 worksheets (Activities #1-4)
- Activity 1: Introduction to Place by Hui Hoʻoleimaluo
  - Wahi pana: Where are you? What is a loko iʻa?
  - Ka'ahele: Walking tour of Waiuli
  - Mo'olelo: The stories of Waiuli (Malo family, etc.)
- Students take freestyle notes in their field books

Explain – (field, 1.5 hours)

- Activity 2: What's in a name? activity and reflection questions
- Activity 3: Mapping the loko iʻa

 L. Mason

Elaborate – (field, 1.5 hours, after lunch)

- Define kuleana. What does this mean to you? What does this mean for our science class?
  - Design STEMS2 mindset: embrace multiple lenses by engaging in authentic, hands-on investigation, problem solving and community service.
- Activity 4: Service project – halihali and helping maintain/build the kuapa activity and reflection questions. Be sure students have gloves and are properly clothed to be comfortable in the cold water.
- Informal presentations of map sketches to the group

Evaluate – (field, 30 min)

- Closing – group discussion
- Review concepts and main ideas for reflection writing
- Return to school (by 3:00pm)

HW: Complete field worksheet questions/ reflections (Activities #1-4), Learning journey reflection 1 draft, Honokea map sketch, read "Loko I'a: Introduction/ Fishpond History"

Classroom Plan – (3 days)

Engage

- 3-2-1 Share: three points to remember, two things you liked, one question you still have about learning journey 1
  - What is a loko i'a? Can loko i'a be built anywhere? Explain.

Explore

- Students read "He 'Aina Momona: The Loko I'a/ Different Types of Loko I'a" student reading
  - What type of loko i'a is Honokea? How do you know?
    - Honokea is a loko i'a kuapā
- Students do "He 'Aina Momona: Student Activity Sheet" using the Hilo, Hawaii island map outline provided. Follow instructions on the handout and include summary.

Explain (or modify with flipped lecture)

- Watch Video: Kumukahi Loko iʻa http://www.kumukahi.org/units/ka_honua/onaepuni/loko_ia
- Notes: Loko I'a: Introduction/ Fishpond History
  - Explain how loko i'a affect local food production for a community
  - Explain how loko i'a serve as ancient evidence of engineering innovation in Hawai'i
  - Explain the main structures of a loko i'a kuapa, as seen at Honokea ('auwai, kuapa, makaha)
  - Read the box containing "Traditional Hawaiian Fishpond Species" on page 7. Do any students recognize these fishes? Read the section on "other principle food items" on pages 11-12.

Elaborate

- Students do "Ka Hana No'eau a nā Kūpuna: Loko I'a Mapping Student Activity Sheet" using field notes and sketch of Honokea from Activity 3 (field day). *Optional: Ahupua'a Mapping Student Activity Sheet*
- Create final versions of Honokea maps and digitize into a shared Google Slides presentation (need laptops)
- *Optional: Share learning journey 1 reflection draft, peer-review*

Evaluate/ HW:

- Complete "He 'Aina Momona: Student Activity Sheet" worksheet
- Complete "Ka Hana No'eau a nā Kūpuna" Loko I'a Mapping Student Activity Sheet"
- Complete learning journey reflection 1
- Practice Paheahea Loko oli for next week

Evidence of Success:
Turn in all work accurately and completely, demonstrate their ability to meet learning objectives, answer guiding questions either verbally or in written form

Notes and Nuances:
Vocabulary: STEMS², mālama ʻāina, laulima, huakaʻi, kiaʻi, moʻolelo, mokupuni, moku, ahupuaʻa, ili, kaiāulu, wahi pana, Waiuli, Honokea, Hale Likikini, Puakahīnano, Umikiʻi, Nālāhiki, Kalahiki nui, Kalahiki iki, Kāiliwai , Hōke, Oli, Kilo, loko iʻa, kuapā, mākāhā, ʻauwai kai, loko kuapā, , loko puʻuone, loko wai, loko iʻa kalo, loko ʻume iki, kāheka, Malo ʻohana, ahu kiʻi, punawai, mahi iʻa, ʻāina, halihali, hoʻo niho, kūkulu, hana

Materials/Resources:
- Loko i'a reading packet
- Kilo 1
- Learning Journey 1 worksheets
- He ʻĀina Momona: The Loko I'a/ Different Types of Loko I'a
- He ʻĀina Momona: Student Activity Sheet
- Hilo map outline
- Field books, graph paper, clipboards, laptops
- Field Trip Evaluation Rubric

Homework:
- Complete field worksheet questions/ reflections (Activities #1-4)
- Read "Loko I'a: Introduction/ Fishpond History" and complete notes
- Complete "He ʻĀina Momona: Student Activity Sheet"
- Complete "Ka Hana Noʻeau a nā Kūpuna: Loko I'a Mapping Student Activity Sheet"
- Complete learning journey reflection 1
- Practice Paheahea Loko oli for next week

Lesson Reflections:
- The PKL resources we are using portray loko iʻa as having surface freshwater connections. We are working in a loko i'a that has groundwater connections in the form of punawai, or freshwater springs. Major distinction.
- Students gain familiarity with the massive amount of Hawaiian vocabulary they learned this week and are developing in their ability to use the vocabulary in context.
- Students are excited to go back to Honokea next week. Their journals show engagement and enthusiasm in learning these concepts.
- They were helpful and had positive attitudes while working in the field and were respectful to our community partner and the place we were at.
- Meet with Kamala to get her feedback on the learning journey. Incorporate her ideas for improvement.

Design STEMS²

Lesson 3 Title: Ecology of Honokea/Mauka-Makai Interactions (Learning Journey 2)
Course: Environmental Science
Teacher(s): Lisa Mason
Duration: 4-5 days

Lesson Objectives:

- Classify abiotic and biotic features of the loko i'a.
- Identify native and alien species found at Honokea.
- Construct a food web showing energy flow between aquatic species found in the loko i'a.
- Analyze the conditions in which loko i'a may be a more efficient source of protein than ocean fishing for early Hawaiians.
- Build umu (fish shelters made of rock) within the pond that are comparable to other umu in the area and that don't collapse when touched.

Standards:

NGSS

- HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

C3

- D2.Geo.4.9-12. Analyze relationships and interactions within and between human and physical systems to explain reciprocal influences that occur among them.

Common Core Math/LA

- WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) to address a question or solve a problem.

Lesson Launch Notes:

- Practice Paheahea Loko oli. *Optional: Nā ʻaumakua*

Lesson Closure Notes:

Exit Pass:

1. What are loko i'a and how are they dependent on the functions of a healthy watershed?
2. How can loko i'a be used by communities to once again provide resources for the benefit of those communities?
3. In what ways do loko i'a serve as ancient evidence of engineering innovation in Hawai'i?

How can scientific, traditional, and community-based approaches be used to protect watersheds, conserve freshwater resources, and help to design innovative solutions for sustainability in Hawai'i?

Lesson Tasks, Problems, and Activities (attach resource sheets):

Learning Journey Plan (1 day)
Engage – (field, 40 min)

- Arrive at Waiuli early morning (8:00am)

- Greeting by Hui Ho'oleimaluo team, setup
- Practice of Paheahea Loko oli. *Optional: Nā ʻaumakua*
- Kilo 2
    - Pass out worksheets with clipboards to students. Allow about 15 min for completion of their kilo individually and quietly. Recommend quiet spaces for observations.

Explore – (field, 1.5 hour)

- Activity 1: Scavenger Hunt
    - Students will complete "Ka Hana Noʻeau a nā Kūpuna: Human Factors Scavenger Hunt" student activity sheet
        - Students can work individually or in pairs to complete this activity, compare answers, and briefly discuss their findings as a group
    - Discuss as a whole group the history of the modern concrete wall that was built by Hawai'i County at Waiuli. How is the modern concrete wall different from a traditionally build wall?
        - Setting rocks together allows for water flow. Traditional methods did not use concrete. The pathways for water flow allowed for filtration and oxygenation of the water, and physical protection of species that could fit in the crevices. The wall also protects from wave action.
- Activity 2: Measuring the Physical Environment
    - Students will complete "Ka Hana Noʻeau a nā Kūpuna: Physical Environment Student Data Sheet". Follow instructions on handout to complete the activity. Extension: Students can develop their own method to estimate the surface area of the pond.
    - What is the function of the kuapā, mākāhā and the ʻauwai kai?

Explain – (field, 40 min)

- Activity 3: Loko Ecology
    - Students may also take freestyle notes in their field books during this activity
    - Gather students around the loko where umu are visible. What does "umu" sound like? Answer: "Imu". How can these two words be similar/different?
    - Explain the function and structure of umu in the loko
        - Umu are fish shelters made out of cylindrically stacked rocks that allow water flow
        - Provide substrate and protection for hapawai and smaller/juvenile fish in the pond
        - Made by humans with rocks already present in the loko
    - Ask students to count the number of umu in the loko. Who made them?
    - Identify the key species in the loko. Distinguish between most common species, native species, alien species, and desirable species present in Honokea
    - Introduce the concept of the 10% rule of energy flow

Elaborate – (field, 1.5 hour)

- Activity 4: Service Project - Building Umu
    - Demonstrate the method of stacking rocks on land. Students practice on land first.
    - Build/rebuild umu in the water. Wear gloves and masks and proper clothing to be comfortable in the cold water.
        - Remind students to be careful of fish and invertebrates in the water during the activity, especially on rocks being used for umu.
    - Note the location of punawai (freshwater spring) in the loko i'a.
- Activity 5: Species ID
    - Optional: Volunteers can collect footage of the biological community (fish, crabs, etc.) and underwater scenery using the GoPro.

Evaluate – (field, 30 min)

- Closing – group discussion
- Review concepts and main ideas for reflection writing
- Return to school (by 1:30 pm)

HW: Complete field worksheet questions/ reflections (Activities #1-4), begin learning journey reflection 2 draft, complete Scavenger Hunt worksheet, complete Physical Environment data sheet, read "Loko I'a: Net-Pen Production (p. 39), Optimizing Pond Health (p.50)"

Classroom Plan – (3-4 days)

Engage –

- 3-2-1 Share: three points to remember, two things you liked, one question you still have about learning journey 2
    - What is an umu?
- Define ʻike. What does that mean to you? What does that mean for our science class?
    - Design STEMS2 mindset: seek to understand the practices of design thinking/ STEMS2 across various cultures and settings, including ancient, traditional, and modern contexts.

Explore –

Reviewing information from Learning Journey 2

- **Physical Dimensions:** Loko i'a around Hawai'i are different
    - Compare measurements in class from "Ka Hana Noʻeau a nā Kūpuna: Physical Environment Student Data Sheet"
        - Calculate averages for 1) dimensions of kuapā, 2) dimensions of ʻauwai kai, 3) flow rates through mākāhā
    - Compare measurements to dimensions of loko i'a around Hawai'i (Keala, 2007, pp. 9-11; Loko I'a Map of Hawai'i)
        - What environmental/ social factors are required for a loko i'a to be built?
        - What factors influence the size of a loko i'a? What factors determine productivity of the loko i'a?
- **Ecological Interactions:** Loko i'a are aquatic ecosystems
    - On the board/ PPT:
        - List species (names, type of organism, habitat, niche) from field notes and provide pictures of species for reference
        - Categorize biotic and abiotic factors in the ecosystem. How do we observe/measure these factors?
- **Human Impacts:** People use loko i'a and Waiuli in different ways
    - Pair-Share: "Ka Hana Noʻeau a nā Kūpuna: Human Factors Scavenger Hunt"
        - Were there any surprising findings? What human activities seem most impactful at Waiuli? Should these activities be permitted/ regulated at Waiuli? Explain using C-E-R form.
    - SOS [Exit Pass Option]: Students write 1) a quick **S**tatement, 2) **O**pinion based on the statement, and 3) a **S**upporting piece of factual evidence about human impacts on the environment at Waiuli

Explain –

Lecture Notes

- **Ecological Interactions:** Energy flow
    - Law of conservation of energy
    - Species interactions and food webs
    - Primary productivity (Keala, 2007, p. 39)
    - Trophic pyramids and the 10% rule (Keala, 2007, p. 50)

Elaborate –

- Create a food web of Honokea showing the flow of energy across trophic levels
  - Insight Maker: https://insightmaker.com/tag/FOOD-WEB
- Create a species ID guide for Honokea to share with Hui Ho'oleimaluo
  - Google Slides
- *Optional: Share learning journey 2 reflection draft, peer-review*

Evaluate –

- Students present their food webs and species ID guide individually or in teams. Use informal presentation rubric.
- Students turn in all worksheets and written assignments
- Students turn in learning journey 2 reflection

Evidence of Success: Turn in all work accurately and completely, demonstrate their ability to meet learning objectives, answer guiding questions either verbally or in written form

Notes and Nuances:
Make sure students understand that 1) loko i'a are manmade but rely on natural resources to stay functional, 2) loko i'a need to be connected to a source of freshwater and are brackish, 3) Honokea is not a "healthy" example of a functioning loko i'a, 4) there are loko i'a around the state that currently use a mix of traditional and conventional methods to enhance fish production, and 5) management of loko i'a are predominately community initiatives that sometimes turn into organized/commercial efforts.

Vocabulary: STEMS², ʻike, anthropogenic, conservation of energy, biological community, biotic/abiotic, endemic, native, non-native (alien), invasive, primary productivity, food web, trophic pyramid, detritus, biomass inefficiency, 10% rule, predator-prey, punawai, umu

Materials/Resources:

- Loko i'a reading packet
- Kilo 2
- Learning Journey 2 worksheets
- Ka Hana Noʻeau a nā Kūpuna: Human Factors Scavenger Hunt
- Ka Hana Noʻeau a nā Kūpuna: Physical Environment Student Data Sheet
- Walking wheel/meter stick/ transect tape, stopwatch, calculator, laptops
- Field books, clipboards, laptops
- Field Trip Evaluation Rubric
- Informal Presentation Rubric

Homework:

- Complete field worksheet questions/ reflections
- Learning journey reflection 2
- Scavenger Hunt worksheet
- Complete Physical Environment data sheet
- Read "Loko I'a: Net-Pen Production (p. 39), Optimizing Pond Health (p.50)"
- Lecture notes
- Food web
- Species ID guide

Lesson Reflections: *How do you know that you were effective? What questions, connected to the lesson standards/objectives and evidence of success, will you use to reflect on the effectiveness of this lesson?*

- Students had positive attitudes while stacking rocks to build umu in the pond. Listed and followed instructions while working with Nāhoku.
- The pond was cold and students needed masks and gloves to be able to work safely and efficiently.
- Need to figure out a way for all students to have opportunity to collect video footage.
- Need to make stronger connections to the "design engineering" concepts.

- Omitted food web activity this round. Hope to include that next time. Students worked slowly and would have needed 1-2 more days to complete that extra assignment.

Design STEMS²

Lesson 4 Title: Water Quality Testing at Honokea (Learning Journey 3)
Course: Environmental Science
Teacher(s): Lisa Mason
Duration: 5-6 days

Lesson Objectives:
- Collect water samples using standard methods. Measure water quality parameters of temperature, dissolved oxygen, pH, salinity, and turbidity using a YSI and turbidity meter. Apply standard field methods for recording field data.
- Formulate an explanation for the variation in water quality measurements between locations in the loko i'a.
- Summarize current scientific research happening at Honokea.
- Critique current restoration efforts at Honokea and Waiuli.
- Draw conclusions on whether loko i'a are/ can be a viable option for food production in Hawai'i.
- Analyze loko i'a in an ahupua'a as an example of Hawaiian ingenuity and innovation.
- Create a collaborative report (summarize, explain, analyze) on the learning journey experiences at Honokea and share with Hui Ho'oleimaluo.

Standards:
NGSS
- HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

C3
- D4.6.9-12. Use disciplinary and interdisciplinary lenses to understand the characteristics and causes of local, regional, and global problems; instances of such problems in multiple contexts; and challenges and opportunities faced by those trying to address these problems over time and place.

Common Core Math/ LA
- RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) to address a question or solve a problem.
- RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
- MP.2. Reason abstractly and quantitatively.
- HSN.Q.A.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN.Q.A.2. Define appropriate quantities for descriptive modeling.

Lesson Launch Notes:	Lesson Closure Notes:
• Make sure to have 4 water samples for Activity 2 already collected • Practice Paheahea Loko oli. *Optional: Nā ʻaumakua*	Exit Pass: 1. How can loko i'a be used by communities to once again provide resources for the benefit of those communities?

● Background reading	2. In what ways do loko i'a serve as ancient evidence of engineering innovation in Hawai'i? **How can scientific, traditional, and community-based approaches be used to protect watersheds, conserve freshwater resources, and help to design innovative solutions for sustainability in Hawai'i?**

Lesson Tasks, Problems, and Activities (attach resource sheets):

Learning Journey Plan (1 day)

Engage – (field, 40 min)

- Arrive at Waiuli early morning (8:00am)
- Greeting by Hui Ho'oleimaluo team, setup
- Practice of Paheahea Loko oli. *Optional: Nā 'aumakua*
- Kilo 3
  - Pass out worksheets with clipboards to students. Allow about 15 min for completion of their kilo individually and quietly. Recommend quiet spaces for observations.
- What are the biotic and abiotic features of a fishpond?
- What does it mean to be "healthy"? What does a "healthy" fishpond look like?

Explore – (field, 1 hour)

- Activity 1: Measuring the Physical Environment (Part 2)
  - Work in teams to record information
  - Students can use phones to look up Hawaiian moon calendar and tide charts
- Activity 2: Introduction to Water Quality
  - Introduce the three scientific instruments for this lab
    - YSI – stands for "Yellow Springs Instrument" company, digital water monitoring system measures multiple variables (DO, salinity, conductivity, temp)
    - Turbidity meter – measures the particulates in water, cloudiness
    - Refractometer – measures the salinity of water
  - Salinity Investigation
    - Students work in pairs to test 4 different water samples for salinity using the refractometers.
      - Tap water, anchialine pool, ocean, in Honokea
    - Freshwater 0ppt, brackish between 0-35ppt, saltwater (ocean) 35-37ppt
    - Have students identify where each sample came from based on salinity measurements

Explain – (field, 1 hour)

- Background reading (student handout)
  - Water quality parameters
  - Explain how to use the three scientific instruments for this lab
- Pond walk w/ Kamala
  - Introduction to two scientific research studies
    - Effects of salinity on primary production in three Hawaiian fishponds
    - Groundwater dynamics in three Hawaiian fishponds

Elaborate – (field, 1.5 hour)

- Activity 2: Water Collection
  - In groups, students are assigned bottles to collect water samples in designated locations.

  - Students will be in water.
    - See map in Activity 2 section, students record bottle codes for each site.
    - Demonstrate how to rinse and submerge bottle to collect an optimal sample.
- Activity 3: Water Quality Testing
  - Students work in groups to record data from water samples. One group of students will use the YSI, another will use the turbidity meter.
  - Keep bottles capped until its time for the measurement to be taken.
  - Record all data in table. Create a Google Sheet to compile student data, calculate stats, and make graphs.
- Optional Activities (1 hour, see handout)
  - Activity 4: Sampling Limu
  - Activity 5: Sampling Plants

Evaluate – (field, 30 min)
- Closing – group discussion
- Review concepts and main ideas for reflection writing
- Return to school

HW: Complete field worksheet reflection questions, begin learning journey reflection 3 draft, review "Loko I'a: Optimizing Pond Health (p.50-53)".

Classroom Plan – (5 days)
Engage – (1 class)
- 3-2-1 Share: three points to remember, two things you liked, one question you still have about learning journey 3
  - What are the 5 parameters of water quality we investigated at Honokea?
  - Would you say that Honokea has high, moderate, or low water quality? Explain.
    - Encourage students with different answers to continue a short discussion and provide evidence for their reasoning (C-E-R)
- Watch: https://youtu.be/-dRlhbm_KDw
  - Venn Diagram: How does our work at Honokea compare to efforts at other loko i'a, for example Paepae O He'eia?

Explore – (1 class)
- Data Analysis in Google Sheets
  - Discuss trends in the data and cause/effect patterns between factors across the loko i'a
  - Use student generated Honokea maps to support analyses
- Create template for Honokea report. Assign writing sections to individual students. Sections will be filled using information from reflections, field notes, past classwork, worksheets and responses to reflection questions.
  - Google Doc
    - Introduction to our class project
    - Site location
    - Physical study of the loko i'a
    - Water quality
    - Species list
    - Human impacts
    - Environmental/ educational activities at Honokea
    - Our environmental assessment of Honokea
    - Future research projects

- Restoration work
- Community involvement

Explain – (1 class)
Lecture notes/ Discussion

- Comparing/ contrasting "science" and "engineering", defining a creative process for innovation
- Loko i'a as examples of Hawaiian ingenuity and innovation: looking to the past to design our future
- A value of sust-ʻĀINA-bility (Loko i'a "Economics of Revitalizing Hawaiian Fishpond Production" pp. 68 – 71)

Elaborate – (1 class)

- Define lōkahi. What does that mean to you? What does this mean for our science class?
  - Design STEMS2 mindset: craft culturally respectful and place-appropriate solutions that are both equitable and empowering for the community/culture you are working in.
- Optional: Fishpond Redesign Activity (intro to Design Thinking) – Materials: poster paper/ markers
  - Students create a utopian version of a loko i'a. Using the venn diagram from *Engage* step, and this redesign as a model, students critique the current situation at Honokea and current work to restore the loko i'a.
  - Complete "Engineering and Innovation – Loko i'a" questions in small groups
- Review "Water Quality Lab/ Species List" report
- Compile information into comprehensive "Honokea Report"

Evaluate – (1 class)

- Complete "Reading and Review Questions from Learning Journeys to Honokea, Waiuli"
- Review of "Honokea Report"
- Part 1 Unit Quiz

Evidence of Success:

- Turned in all work accurately and completely, demonstrated their ability to meet learning objectives, answered guiding questions either verbally or in written form.
- Completed assigned sections of collaborative Honokea report. Followed up with comments on report for improvements or corrections.
- Present report to our community partner Hui Ho'oleimaluo.

Notes and Nuances:

Vocabulary/ concepts: STEMS^2, lōkahi, scientific prediction, independent variable, dependent variable, true/controlled experiment, quasi/natural experiment, water quality parameters (studied during learning journey), primary productivity, YSI, turbidity meter, refractometer, phytoplankton, eutrophication, engineering innovation, primary scholarly research, local ecological knowledge, economic model, fishpond revitalization, agricultural economy, ecosystem services, environmental/ cultural rehabilitation

Typical misconceptions: loko i'a are impractical, irrelevant, "dormant ocean farms" (Keala, 2007, p. 65), there are more efficient methods for fish production, conventional commercial methods are better, general lack of earth-systems understanding

Materials/Resources:

- Loko i'a reading packet
- Kilo 3
- Learning Journey 3 worksheets
- Refractometers (x3)
- Dark plastic bottles with labels
- Laptops with internet access
- Video: https://youtu.be/-dRlhbm_KDw

● Walking wheel/meter stick/ transect tape, stopwatch, calculator, laptops ● Field books, clipboards, laptops ● Field Trip Evaluation Rubric ● YSI/ Turbidity meter	● Poster paper/ markers (optional) ● Worksheet: Engineering and Innovation – Loko i'a ● Worksheet: Reading and Review Questions from Learning Journeys to Honokea, Waiuli ● Part 1 Unit Quiz
Homework: Continuation of classwork and report writing	
Lesson Reflection (overview Phase 1): ● Did I support students in developing their sense of place at Honokea? In Hawaii? ● Was there enough time to complete all the activities in this unit? Did the field work support the classroom work, and vice versa? ● Are students engaged and excited about their investigation, service, and findings at Honokea? ● Do students see Honokea as a place of authentic scientific practice? How? ● Do students understand the mauka-makai connection between our watersheds and coastlines in Keaukaha? ● Do students understand the current and potential value of loko i'a in Hawai'i? ● Do students see loko i'a as an example of Hawaiian engineering design and innovation? ● Can students articulate the value of ecosystem services and loko i'a for a sustainable Hawai'i?	

Lesson 5 Title: Design Challenge Hack
Course: Environmental Science
Teacher(s): Lisa Mason
Duration: 2 days

Lesson Objectives:

- Compare/contrast *design* and *design thinking*.
- Compare/contrast the scientific method with design thinking.
- Define *wicked problems* and give examples.
- Identify the 7 mindsets of design thinking.
- Define the terms *iteration* and *prototype* in relation to design thinking.
- Define the 5 steps of the Stanford design thinking method.
- Distinguish between a problem-centric approach (false-start) and a human-centered approach in problem solving.
- Apply the methodology of design thinking to redesign an object based on user need.

Standards:

<u>NGSS</u>

- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

<u>C3</u>

- D1.5.9-12. Determine the kinds of sources that will be helpful in answering compelling and supporting questions, taking into consideration multiple points of view represented in the sources, the types of sources available, and the potential uses of the sources.

<u>Common Core Math/LA</u>

- WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- WHST.9-10.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

Lesson Launch Notes:

- Introduce the next two days as a transition between Phase 1 and Phase 2 of our learning journey (unit).
- We are moving into the next phase of engineering design and design thinking.
- For this lesson plan I used the Wallet Project as my design hack. There are many other possibilities such as redesigning a better classroom, etc.
- What is a design "hack"?
- Pass out student handout for Wallet Project

Lesson Closure Notes:

Exit Pass:

1. How is Design Thinking different than simply "design" or "engineering"?
2. What are the 5 steps in the Design Thinking method?
3. What are the 7 mindsets of Design Thinking?

How can scientific, traditional, and community-based approaches be used to protect watersheds, conserve freshwater resources, and help to design innovative solutions for sustainability in Hawai'i?

Lesson Tasks, Problems, and Activities (attach resource sheets):

Engage – (10 min)

- What is a design hack?

- The Wallet Story

Explore – (45 min)

- Work through the Wallet Project facilitator guide.
    - Sketch your ideal wallet
    - Interview to gain empathy
    - Define the problem using user insight
    - Ideate to visualize alternatives
    - Test to gather feedback
    - Iterate with a physical prototype
    - Re-define your point of view
    - Reflect

Explain – (20 min)

- Explain the structure and purpose of the Design Thinking Digital Notebook
- Setup Design Thinking Digital Notebook
- Lecture
    - PTT: What is design thinking?
        - Design and design thinking
        - Scientific method and design thinking
        - Stanford Design Thinking, process and mindsets
        - Wicked problems with examples
        - 7 mindsets of design thinking
        - Iteration and prototyping
        - Problem-centric approach (false-start) versus a human-centered approach

Elaborate – (15 min)

- Discuss the S-T-E-M-S² of their design during the making of the project.
- Talk-story: informal sharing of wallet designs and insights learned using design thinking

Evaluate – (online)

- Design Thinking Digital Notebook – reflection questions (HW):
    - Was your first wallet and your final wallet the same? Why or why not?
    - Did your prototype test change your understanding of your design?
    - What would happen if you did another iteration (see partner feedback)?
    - Did you have a partner who created something that you really liked (physically or conceptually?)
    - Did you see a prototype from our class that contained a feature that you are curious to learn more about?
    - How did talking to your partner inform your design?
    - How can testing and getting feedback help to improve your design?
    - What was the most challenging part of the process for you?
    - How is this different from a traditional project approach?
    - In order to complete the design of your wallet (final form), how do you think that science/technology/engineering/math (STEM) are involved? What STEM concepts are evident in this Design Thinking challenge?
    - Consider the following phrases. <u>Choose one phrase</u> to elaborate on (3-5 sentences) below in the context of our “wallet” activity.
        - Human-centered design: empathy for the person or people you are designing for, and feedback from users, is fundamental to good design.
        - Experimentation and prototyping: prototyping is not simply a way to validate your idea; its an integral part of your innovation process. We build to think and learn.

- A bias towards action: Design thinking is a misnomer; it is more about doing than thinking. There is a bias towards doing and making, versus thinking and meeting.
- Show don't tell: Creating experiences, using illustrative visuals, and telling good stories communicate your vision in an impactful and meaningful way.
- Power of iteration: The reason why we go through this exercise at a frantic pace is that I want you to experience a full design cycle, with some modification. A person's fluency with design thinking is a function of cycles. Iterating solutions many times within a project is key to successful outcomes!

Evidence of Success:

- Turn in all work accurately and completely, demonstrate their ability to meet learning objectives, answer guiding questions either verbally or in written form, apply the methodology of design thinking to redesign an object based on user need
- Design Thinking Notebook is up-and-running.

Notes and Nuances:

Vocabulary: STEMS^2, design, design thinking, wicked problems, design thinking mindsets, human-centered, mindful of process, focus/flare, culture of prototyping, show don't tell, craft clarity, bias towards action, radical collaboration, empathize, define, ideate, prototype, test, false-start

Misconceptions: design and design thinking are the same, creativity is limited when we apply structure and process, our ideal designs are the best solution to the problem

Often, the term prototype is interchanged with the term "model," which can cause confusion. While several types of prototypes exist, for the purpose of this activity, we will make the following distinction: Whereas a model is used to demonstrate or explain how a product will look or function, a prototype is used to work out the kinks in a design or to try new ideas. Keep in mind that prototypes are unrefined versions of a future product. Most companies do not show prototypes to the general public to ensure that the public's opinion is based on the final product.

In some cases, engineers "rapid prototype" a part. Rapid prototyping is the automatic construction of physical objects using additive manufacturing technology and computer-aided design (CAD) software. (www.teachengineering.org)

Materials/Resources:

- Wallet Project facilitators guide and student packet
- "Designers Kit" – filled with all kine arts and crafts stuff
- Laptops with internet access

Homework:

Homework/ Workspace:

Write your point of view statement from your in-class interview here:

Prototype photos w/ explanations:

Description:

Feedback from classmate during Testing phase:

- Design hack reflection questions in digital notebook
- Where is the STEMS^2? worksheet

Lesson Reflections:

- Were students engaged during all parts of the lesson?

- Did students use the hands-on part of the lesson effectively?
- Did they stay true to the process and incorporate their "users" personal stories into the design concept? Was empathy a focus of the hack?
- Was the relationship between the fields of science and engineering strongly established (STEMS^2)?
- How can the relationship between innovative engineering design and community change be strengthened in this lesson?

Design STEMS²

Lesson 6 Title: Design Thinking a Better Campus
Course: Environmental Science
Teacher(s): Lisa Mason
Duration: 3 days

Lesson Objectives: ● Categorize society's uses of freshwater by sector and determine the impacts of agriculture on water resources. ● Recognize local and global issues related to freshwater resources, usage, conservation, and identify current technological solutions. ● Apply design thinking concepts to identify a relevant need of our school community related to our freshwater use and sustainability. ● Create a list of questions and conduct an interview to empathize with a school community member on an issue related to freshwater resources on campus. Standards: <u>NGSS</u> ● HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. ● HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. ● HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. ● HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. <u>C3</u> ● D1.5.9-12. Determine the kinds of sources that will be helpful in answering compelling and supporting questions, taking into consideration multiple points of view represented in the sources, the types of sources available, and the potential uses of the sources ● D4.6.9-12. Use disciplinary and interdisciplinary lenses to understand the characteristics and causes of local, regional, and global problems; instances of such problems in multiple contexts; and challenges and opportunities faced by those trying to address these problems over time and place. <u>Common Core Math/LA</u> ● WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. ● WHST.9-10.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.	
Lesson Launch Notes: ● It is important to reiterate the theme and essential question of the unit at the beginning of this lesson. The theme is freshwater resources and conservation. The Engineering Design Challenge will be built on the themes of freshwater conservation we explored in Phase 1.	**Lesson Closure Notes:** Exit Pass: 1. Why is Design Thinking considered to be a human-centered approach to problem solving? 2. How can local knowledge of a problem help designers to create culturally appropriate solutions for our community?

• This lesson is the introduction to the Engineering Design Challenge at CLA (Phase 2) STEP: ALOHA - EMPATHIZE	**How can scientific, traditional, and community-based approaches be used to protect watersheds, conserve freshwater resources, and help to design innovative solutions for sustainability in Hawai'i?**

Lesson Tasks, Problems, and Activities (attach resource sheets):

****Bright green environmentalism** is an ideology based on the belief that the convergence of technological change and social innovation provides the most successful path to sustainable development.

Engage – (10 min)

- Define aloha. What does it mean to you?
  - Design STEMS^2 Mindset: empathize through the 3Ps (time period, place, and people) via place-based, community-based partnerships
- Watch TED Video: Richard Turere: My Invention that made Peace with Lions https://youtu.be/RAoo--SeUIk
  - What was the cause of Richard's motivation to create his invention?
  - Whose needs did Richard empathize with?
  - How did Richard come to understand the problem at hand?

Explore – (45 min)

- Video: Test Your Observation – Whodunnit https://youtu.be/8-hapS2SPz4
- Activity: "Aloha Grown - Empathizing with our community needs"
  - Walk to greenhouse with class.
    - Worksheet: "Greenhouse Observations"
    - Worksheet: "Greenhouse Mapping"
  - Identify the primary "users" of our greenhouse (Mr. P and Mr. B)

Online-

- *Review Lecture Notes PPT: Introduction to Design Thinking (online HW)*
  - *https://lmasoncla.files.wordpress.com/2018/02/intro-to-design-thinking.pdf*
- *Watch Water Conservation Videos (online HW) -*
  - *TED Ed Freshwater Scarcity: https://youtu.be/otrpxtAmDAk*
  - *TEDx Ms. Smarty Plants: https://youtu.be/roamDLEFhhc*
  - *Watershed: https://youtu.be/LfNok2lp1LA*

Explain – (30 min)

- Students take notes and respond to questions in Design Thinking Digital Notebook
- Discussion: Applying Design Thinking in our Community (in-class) – Lessons from Richard Turere
  - Foundation of Design Thinking = Community
  - Communities exist in places. People + places = culture.
  - Your community is a component of your culture.

Elaborate – (50 min)

- Discuss the S-T-E-M-S^2 of their design during the empathize process.
- Think-Pair-Share: Applying Design Thinking in our Community
    - Write your definition for culture. Write your definition for community.
    - Do you feel a sense of responsibility to positively impact your community? How so?
    - What types of problems are there in your community that you would like to see solved?

- How do you think Design Thinking could be used to help create a solution to that community problem or need?
- How can local knowledge of a problem help designers to create culturally appropriate solutions for that community?

- User interview – Worksheet: "Empathizing through Interviewing"
  - Pre-HW: In the interview questions section of your Design Thinking Digital Notebook, make a list of 10 interview questions for the greenhouse manager about our school's greenhouse.
  - Facilitate students' interview with the greenhouse manager
    - Record interview and post online with link in Design Thinking Digital Notebook for students to access later for HW

Empathize

- **Interview** 2. **Dig Deeper (optional)**

Notes from 1st interview - Mr. Pratt (in-class)	Notes from 2nd interview

Evaluate – (online)
- Design Thinking Digital Notebook questions
- Design Thinking Concept Check

Evidence of Success:
- Turn in all work accurately and completely, demonstrate an ability to meet learning objectives, answer guiding questions either verbally or in written form.
- Interview questions and interview behaviors are respectful and reflect students' understanding of the process.
- Students work together to create a set of interview questions that go beyond inquiring about a "watering system in the greenhouse" and tap into the deeper stories of our greenhouse manager and our school.

Notes and Nuances:

Vocabulary: STEMS^2, aloha, empathize, community, culture

Materials/Resources:
- TED Video: Richard Turere: My Invention that made Peace with Lions
- Video: Test Your Observation – Whodunnit
- Worksheet: "Greenhouse Observations"
- Worksheet: "Greenhouse Mapping"
- PPT: Introduction to Design Thinking
- TED Ed Video: Freshwater Scarcity https://youtu.be/otrpxtAmDAk
- TEDx Video: Ms. Smarty Plants https://youtu.be/roamDLEFhhc
- Video: Watershed https://youtu.be/LfNok2lp1LA

Homework:
- Applying Design Thinking in our community discussion questions
- Interview questions
- Design Thinking concept check
- Where is the STEMS^2? worksheet

● Worksheet: "Empathizing through Interviewing" ● Design Thinking Notebooks ● Laptops with internet connections	

Lesson Reflections:

- Were students' interview questions and interview behaviors respectful and reflect students' understanding of the process?
- Did students work together to create a set of interview questions that go beyond inquiring about a "watering system in the greenhouse" and tap into the deeper stories of our greenhouse manager and our school?
- Did students empathize through the 3Ps (time period, place, people) via place-based, community-based partnerships?

Design STEMS²

Lesson 7 Title: Design Engineering Challenge – Creating a POV Problem Statement
Course: Environmental Science
Teacher(s): Lisa Mason
Duration: 2 days

Lesson Objectives:
- Create a point-of-view statement that provides insight on a genuine need of the school community.
- Create a problem statement for the Design Engineering Challenge (DEC) from a community member's point-of-view statement.

Standards:
<u>NGSS</u>
- HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

<u>C3</u>
- D1.5.9-12. Determine the kinds of sources that will be helpful in answering compelling and supporting questions, taking into consideration multiple points of view represented in the sources, the types of sources available, and the potential uses of the sources.
- D4.6.9-12. Use disciplinary and interdisciplinary lenses to understand the characteristics and causes of local, regional, and global problems; instances of such problems in multiple contexts; and challenges and opportunities faced by those trying to address these problems over time and place.

<u>Common Core Math/LA</u>
- WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- WHST.9-10.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

Lesson Launch Notes:
- Recorded a screencast video for this lesson. Posted online and available as a link in Design Thinking Notebook.

STEP: WEHEWEHE - DEFINE

Lesson Closure Notes:
Exit Pass:
1. What are the 5 steps in the Design Thinking method? What are the 7 mindsets of Design Thinking?
2. Why did we interview Mr. P?

How can scientific, traditional, and community-based approaches be used to protect watersheds, conserve freshwater resources, and help to design innovative solutions for sustainability in Hawai'i?

Lesson Tasks, Problems, and Activities (attach resource sheets): *What specific activities, investigations, problems, questions, or tasks will students be working on during the lesson?*

Engage – (15 min)

- Define wehewehe. What does that mean to you?
    - Mindset: seek to understand the practices of design thinking/ STEMS2 across various cultures and settings, including ancient, traditional, and modern contexts
- Design Thinking Notebook section:

Define

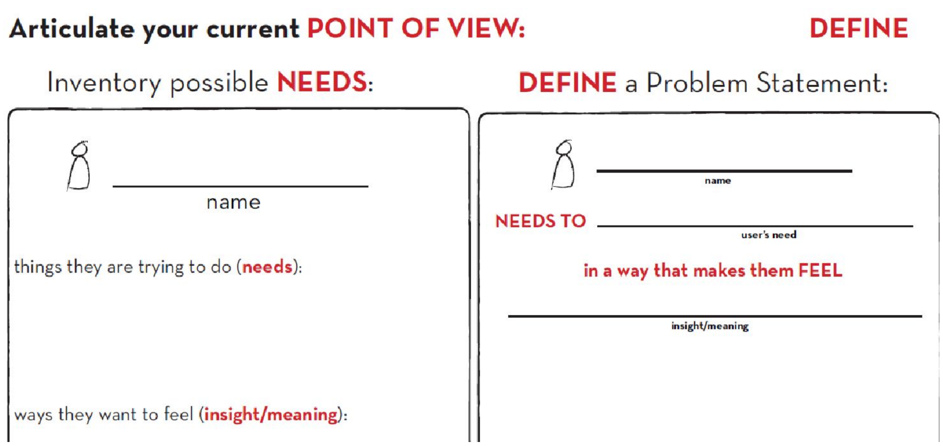
3. Capture Findings

Goals and wishes:	Insights:
Answers will vary	Answers will vary

Explore – (30 min)

- POV Madlib (https://dschool-old.stanford.edu/groups/k12/wiki/22e39/POV_Madlibs.html)
    - A POV Madlibs is a tool to guide the designer through the process of synthesizing the needs and insights from the empathize stage.
        - The define stage is arguably the most challenging stage of the design process and the madlib creates a clear structure through a fill-in-the-blank sentence to define a challenge.
- Use the following the madlib to capture and harmonize three elements of a POV: user, need, and insight.
    - [USER] needs to [USER'S NEED] because [SURPRISING INSIGHT]

- *POV: "CLA needs a cost-effective, efficient, and sustainable watering system in the greenhouse to improve growing conditions and survivability of plants for sale and use as part of our school's educational programs."*



- A good POV will help create How-Might-We (HMW) questions based on your POV

Explain – (30 min)

- Creating a POV
    - A point-of-view (POV) is your reframing of a design challenge into an actionable problem statement that will launch you into generative ideation.
- Watch Tutorial Video: Design Thinking POV Problem Statement https://youtu.be/1WH3Z9yzIqw

Elaborate – (15 min)
- Discuss the S-T-E-M-S^2 of their design during the making of the POV statement.
- Design Thinking Notebook Define section:

4. Develop a point-of-view statement

Specifically state the meaningful challenge that we as a class are going to take on! This is the statement that we are going to address with our design, so make sure its actionable! Use the template below for guidance.

Example: _______________(name) _____________ needs a way to _____________ (user's need)_________ because (or but, or surprisingly…)_________________.

Evaluate – (online)
- Design Thinking Notebook section final POV

Evidence of Success:
- Turn in all work accurately and completely, demonstrate their ability to meet learning objectives, answer guiding questions either verbally or in written form.
- POV statement is a directly actionable and defines the problem for the current iteration of the design thinking process. The problem is based on an authentic need of an authentic user.

Notes and Nuances:

Vocabulary: STEMS^2, wehewehe, point-of-view statement, authentic user

Materials/Resources:	**Homework:**
• Madlib worksheet • Empathy interview • Design Thinking Notebook • Laptops with internet access	• Madlib worksheet • Design Thinking Notebook Define section completion • Where is the STEMS^2? worksheet

Lesson Reflections:
- Is the POV statement directly actionable and define a meaningful problem for the current iteration of the design thinking process?
- Is the problem based on an authentic need of an authentic user in our community?
- Are students being mindful of process and radically collaborating in the team?

Design STEMS²

Lesson 8 Title: Design Engineering Challenge – Ideating Possible Solutions (Creative Brainstorming)
Course: Environmental Science
Teacher(s): Lisa Mason
Duration: 3 days

Lesson Objectives:

- Investigate current irrigation system designs and identify key features that may be useful in this project.
- Apply green light thinking to generate radical solutions to the DEC problem. Effectively use materials (post-it notes, sketches, etc.) to visualize ideas during the brainstorming process.
- Apply red light thinking to systematically choose one solution to move forward for prototyping.

Standards:
NGSS

- HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
- HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

C3

- D1.5.9-12. Determine the kinds of sources that will be helpful in answering compelling and supporting questions, taking into consideration multiple points of view represented in the sources, the types of sources available, and the potential uses of the sources.
- D4.6.9-12. Use disciplinary and interdisciplinary lenses to understand the characteristics and causes of local, regional, and global problems; instances of such problems in multiple contexts; and challenges and opportunities faced by those trying to address these problems over time and place.
- D2.Geo.4.9-12. Analyze relationships and interactions within and between human and physical systems to explain reciprocal influences that occur among them.
- D2.Eco.2.9-12. Use marginal benefits and marginal costs to construct an argument for or against an approach or solution to an economic issue.

Common Core Math/LA

- WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- WHST.9-10.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

Lesson Launch Notes:	Lesson Closure Notes:
● Review POV statements for project. ● Create anchor charts with poster paper around the classroom. STEP: PUAʻI MANAʻO - IDEATE	Exit Pass: ● Was my prototype more a “looks like” prototype or a “works like” prototype? Why? ● What are the limitations and constraints of a prototype?

	How can scientific, traditional, and community-based approaches be used to protect watersheds, conserve freshwater resources, and help to design innovative solutions for sustainability in Hawai'i?

Lesson Tasks, Problems, and Activities (attach resource sheets): *What specific activities, investigations, problems, questions, or tasks will students be working on during the lesson?*

Engage – (20 min)

- Define puaʻi manaʻo. What does that mean to you? What is its connection to our science class?
- Small groups (2-3 students)
    - CDC: https://www.cdc.gov/healthywater/other/agricultural/types.html
    - Types of Irrigation: http://www.togetherweconservelandscape.com/Garden-Resources/IrrigationType.php
    - Water Resources: Bozeman Science: https://youtu.be/IDAj5T1ST7o
- 10-min brainstorm
    - Write/ draw on post-it notes to show possible solutions to the problem statement. Stick post-it notes on anchor charts (poster paper) around class.
    - Green light thinking = effective brainstorming

Explore – (25 min)

- Ideate - Sketching
    - Watch Tutorial Video: https://youtu.be/1WH3Z9yzIqw
- Sketch at least 5 radical ways to meet the user's needs on a separate piece of paper.
- Copy in the designated table in the Design Thinking Notebook. Insert a text explanation and photo of each idea.

Explain – (15 min)

- Design Thinking Principles:
    - Build to decide (rather than to debate)
    - Build with a question in mind, such as, "does this meet the need?" (rather than building simply for the sake of building)
    - Carry 2 possible prototypes forward
    - Make rough and rapid visualizations
    - Prototypes come in make types: look, feel, interact, work

 L. Mason

Elaborate – (35 min)

- Discuss the S-T-E-M-S² of their design during the ideate process.
- Create a crude visualization of an initial prototype using craft materials for a "works-like" or "looks-like" model.
  - Assess briefly the conceptual quality of your prototype and what you would change.
  - Was my prototype more a "looks like" prototype or a "works like" prototype? Why?

Evaluate – (45 min)

- Critique visualizations as a group: "Looks Like/ Works Like" Students share their designs with the class.
  - Looks Like:
    - Did I show all the working components?
    - Did I show a proper scale for all parts?
    - Did I show a proper context (greenhouse/ how it is connected)?
  - Works Like:
    - Did I test the prototype?
    - Did I explain how it works?
    - Did I address the limitations of the design?
- Record responses in Design Thinking Notebook.
- Assign Design Thinking Concept Check

Evidence of Success:

- Turn in all work accurately and completely, demonstrate their ability to meet learning objectives, answer guiding questions either verbally or in written form.

- Decide as a group on a model for prototyping in preparation for next lesson.

Notes and Nuances: *Vocabulary, connections, common mistakes, typical misconceptions, etc.*

Vocabulary: STEMS², puaʻi manaʻo, ideate, brainstorming, "looks-like" vs. "works-like" models, prototypes, show don't tell, craft clarity, bias towards action, radical collaboration

Materials/Resources:

- "Designers Kit" – filled with all kine arts and crafts stuff
- Design Thinking Notebook
- Design Thinking Concept Check
- Laptops with internet access

Homework:

- Record responses in Design Thinking Notebook
- Design Thinking Concept Check
- Where is the STEMS²? worksheet

Lesson Reflections:

- Were students able to work together to create, explain, and decide on a feasible prototype idea? Did they understand that they will be creating this prototype during the next class? Are the materials for the design available locally or can they be ordered in a timely manner?
- Did students seek to understand the practices of design thinking/STEMS2 across various cultures and settings, including ancient, traditional and modern contexts?
- Did students craft culturally respectful and place-appropriate solutions that are both equitable and empowering for the community/culture we are working in?

Design STEMS²

Lesson 9 Title: Design Engineering Challenge – Creating a Prototype/ Iteration
Course: Environmental Science
Teacher(s): Lisa Mason
Duration: 8 days

Lesson Objectives:

- Build and critique a prototype of a watering system for the school's greenhouse.
- Identify and explain the function of all materials and tools required for prototyping. Demonstrate ability to use all materials and tools safely, effectively, and efficiently.
- Apply concepts of pressure and fluid dynamics to design and build a prototype of a watering system.
- Revise the prototype design based on functionality and testing.

Standards:
NGSS

- HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

C3

- D1.5.9-12. Determine the kinds of sources that will be helpful in answering compelling and supporting questions, taking into consideration multiple points of view represented in the sources, the types of sources available, and the potential uses of the sources.
- D4.6.9-12. Use disciplinary and interdisciplinary lenses to understand the characteristics and causes of local, regional, and global problems; instances of such problems in multiple contexts; and challenges and opportunities faced by those trying to address these problems over time and place.
- D2.Geo.4.9-12. Analyze relationships and interactions within and between human and physical systems to explain reciprocal influences that occur among them.

Common Core Math/LA

- WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- WHST.9-10.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

Lesson Launch Notes:

- Students spend time finishing their visualizations from last class and present to the class their prototype design.
- Students complete Prototype Section - Part 1 in Design Thinking Notebook.

Design Thinking Notebook:

- Prototype Section - Part 1: Reflection

Lesson Closure Notes:

- Students will practice operating their prototype in preparation for their presentation to the users (greenhouse managers)
- Students will review their checklist and cleanup their area.
- Check to confirm that users for prototype testing are scheduled for the demonstration. Confirm place and time.

How can scientific, traditional, and community-based approaches be used to protect watersheds, conserve

o What have you learned in our design thinking unit that you didn't know before? o How have you applied this new learning in a new way? o What questions do you have about our design engineering challenge? o Is there any part of our project currently that inspires you? STEP: ANA – PROTOTYPE	**freshwater resources, and help to design innovative solutions for sustainability in Hawai'i?**

Lesson Tasks, Problems, and Activities (attach resource sheets):

Engage – (1 day)

- Define ana. What does that mean to you?
- Pass out Watering System Components: Parts List handout.
  - Introduce students to the major and minor materials they will use to make their design. Fill in missing information on the worksheet.
  - Explain the procedure for organizing and using materials during the project. Take materials to the greenhouse.
- Group read the Design Thinking Key Physics Concepts handout.
  - Why does putting your finger over the tip of the hose make the water shoot out faster and farther?
- Students complete Prototype Section - Part 2 in Design Thinking Notebook for homework.

Design Thinking Notebook:

- Prototype Section - Part 2: Review the information on the following hydrodynamics concepts:
  - Watch Video 1 on fluid flow and answer the review question: https://youtu.be/zgE0iNYw0JA
    - Volume Rate of Flow and the Continuity Equation: A1V2 = A2V2
    - When water is flowing through a container, the volume rate of flow is constant throughout the system. This means that every second, the volume of water flow in is equal to the volume of water flow going out.
      - Example Question: An irrigation tube with an area of 0.08m2 contains water that is flowing with a velocity of 0.6 m/s. The tube's area is reduced to 0.04m2. What is the new velocity of the water in the smaller tube?
  - Watch Video 2 on fluid pressure and answer the questions below: https://youtu.be/7GxtxOCeHbg
    - What unit will our pressure gauge measure in?
    - What will happen if the pressure in our system is too low?
    - What will happen if the pressure in our system is too high?
    - What is the recommended time of day, and under what circumstances, should you water your plants?
    - The natural pressure in our main pipe should be in what range of values?
  - Watch Video 3 on Bernoulli's Equation and answer the review questions: https://youtu.be/fJefjG3xhW0
    - At points along a horizontal streamline, higher pressure regions have lower fluid speed and lower pressure regions have higher fluid speed.
    - What does it mean for a fluid to be incompressible?
    - Does water have a higher or lower viscosity than honey?
    - In our study of fluids, which two properties are we ignoring about the fluid?

- Does the pressure of a fluid on the walls of a pipe increase or decrease as the fluid moves faster?
- Does the velocity of a fluid in a tube increase or decrease as its pressure decreases?
- What are the two forms of energy that are expressed within the terms in Bernoulli's Equation?
- How can Bernoulli's equation help us in our watering system design in the greenhouse?

Explore/Explain – (3 days)

- Create a collaborative blueprint of the prototype plan. Use poster paper or online tool.
- Students can work in the greenhouse to create their prototype using their updated plan. Supervise and answer questions. Make recommendations as needed. Encourage students to work together and communication with each other.
- Be sure to bring students together at least once during their work time for a "2-min check-in" for understanding.
- Allow for 5-min debrief at the end of class each day.

Elaborate – (2 days)

- Discuss the S-T-E-M-S^2 of their design during the making of the prototype.
- Continue working on prototype.
- Students complete Prototype Section – Part 3 in Design Thinking Notebook for homework.

Design Thinking Notebook

- Prototype Section - Part 3: Critical Analysis of Greenhouse Water System Prototype
    - Watch the video interview with Mr. Pratt: https://youtu.be/sKBm4rCNIwM
    - Study each of the pictures of the watering system.
    - For each picture, write a thoughtful description and analysis statement about the element/component. Use these guidelines to write your statements:
        - What is the purpose of this component, as shown? Explain.
        - How can this component/ layout, as shown, be improved by our team? Explain.
        - What was your role in constructing this component? Explain.
            - Picture 1: Tubes running across table and held up by PVC frame
            - Picture 2: Placement of tubing along the side of the greenhouse
            - Picture 3: Hose hook up.

Evaluate – (2 days)

- Pass out Testing the Prototype "YES TEST" Checklist.
    - User Testing: To simulate user testing, have the team split into two groups. One team plays the role of the user and the other team of the designer. Ask teams to give each other feedback:
        - Is the prototype functional? What works? What does not work?
        - Is the prototype used to explore several design alternatives?
        - What improvements could be made?
        - Reflection: After user testing, ask the design teams to reflect on the feedback received. Have them write short documents for the teacher summarizing the feedback and what changes they intend to make in the next iteration of their designs.
- Correct and discuss responses to parts 2 and 3 in Design Thinking Notebook in class.
- Online Quiz

Evidence of Success:

- Turn in all work accurately and completely, demonstrate their ability to meet learning objectives, answer guiding questions either verbally or in written form.

- Pass quiz.
- Students created a functioning prototype and are mindful of their stage in the design engineering process.

Notes and Nuances:
Vocabulary: STEMS^2, ana, prototype, continuity equation, bernoulli's principle/ Venturi effect (www.teachengineering.org)

- *Bernoulli Principle:* In fluid dynamics, Bernoulli's principle states that for an inviscid flow, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. Named after Dutch-Swiss mathematician Daniel Bernoulli who published his principle in his book Hydrodynamica in 1738. Also called the Bernoulli effect.
- *inviscid flow:* Flow in which one can ignore the effects of fluid viscosity.
- *streamline:* A line tangent to the flow of a fluid at any given instant.
- *Venturi effect:* The reduction in fluid pressure that results when a fluid flows through a constricted section of pipe. As a fluid's velocity increases, its pressure decreases, and vice versa. Named after Italian physicist Giovanni Battista Venturi (1746–1822).

Optional Guided Discussions/ Extensions (www.teachengineering.org):
Limitations to Prototypes - Have student teams brainstorm the limitations of prototypes and generate lists of ideas. Engage the class in a discussion of these limitations and expand the discussion to talk about what can be done to accurately determine these factors for final production. For example, limitations might include evaluating costs, time to build, material function and actual environmental impact.

Investigating Questions - Use the following discussion questions to help students gain understanding of an important aspect of engineering problem solving: creating and testing prototypes.

- What is an advantage of building a prototype prior to full-scale manufacturing? (Possible answer: Exploring design alternatives with a prototype saves resources [time, money and materials] required to manufacture a final product.)
- Why might most engineering companies refrain from releasing a prototype to the general public? (Possible answer: Because they want the public's opinions to be based on the final product, not on early versions and rudimentary prototypes.)

Materials/Resources:

- Materials for building (e.g., tubing, PVC, etc.)
- Watering System Components: Parts List handout
- Design Thinking Key Physics Concepts handout
- Where is the STEMS^2? Worksheet
- Design Thinking Notebook
- Laptops with internet access
- Quiz

Homework:

- Complete sections and questions in Design Thinking Notebook from class.
    - Bernoulli's Equation Problems
- Where is the STEMS^2? worksheet

Lesson Reflections:

- Did students create a functioning prototype of their design? Did they use their time wisely in the greenhouse? Were they efficient users of materials?
- Did students embrace multiple lenses by working with each other through this project?
- Do students understand/believe that their design is beneficial to their community? Are they able to communicate a positive response regarding the efficacy of the project?

Design STEMS²

Lesson 10 Title: Design Engineering Challenge – User Testing in Real Life (Final)
Course: Environmental Science
Teacher(s): Lisa Mason
Duration: 2 days

Lesson Objectives:

- Test the prototype with actual users.
- Assess the ability of the design product to meet the need(s) of the user(s) as stated by the DEC problem.
- Critique the design product using feedback from users and formulate ideas for future improvements.
- Cite evidence for how complex problems can be broken down into manageable design challenges.
- Draw conclusions about the importance of science, technology, engineering, math, culture, and community in designing innovative solutions for a sustainable future.

Standards:

NGSS

- HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts
- HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

C3

- D1.5.9-12. Determine the kinds of sources that will be helpful in answering compelling and supporting questions, taking into consideration multiple points of view represented in the sources, the types of sources available, and the potential uses of the sources.
- D4.6.9-12. Use disciplinary and interdisciplinary lenses to understand the characteristics and causes of local, regional, and global problems; instances of such problems in multiple contexts; and challenges and opportunities faced by those trying to address these problems over time and place.
- D2.Geo.4.9-12. Analyze relationships and interactions within and between human and physical systems to explain reciprocal influences that occur among them.
- D2.Eco.2.9-12. Use marginal benefits and marginal costs to construct an argument for or against an approach or solution to an economic issue.

Common Core Math/LA

- HSN.Q.A.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- WHST.9-10.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- WHST.9-10.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

Lesson Launch Notes:	**Lesson Closure Notes:**
● Fist to five: Rate your understanding of the design thinking process.	Reflection Questions for Homework:

STEP: HŌʻIKE – TEST	1. Solving complex, real-world problems can be a messy process and we don't always know what the correct answer is. These types of "ill-defined, wicked" problems are common in the fields of design and engineering. **Did our Greenhouse Engineering Design Challenge count as a "wicked" problem?** 2. Complex, real-world problems can be solved by breaking them down into smaller more manageable design challenges that can be solved through engineering. **Explain how our school's greenhouse watering system is connected to the larger issue of freshwater resource conservation.** 3. How can we embrace multiple lenses and engage in authentic, hands-on investigations, problem solving and community service in our community? 4. How can we craft culturally respectful and place-appropriate solutions that are both equitable and empowering for the community/culture we are working in? 5. How do we ffocus on both the long-term and short-term processes that define culture and spur innovation on Hawaiʻi Island? **How can scientific, traditional, and community-based approaches be used to protect watersheds, conserve freshwater resources, and help to design innovative solutions for sustainability in Hawai'i?**

Lesson Tasks, Problems, and Activities (attach resource sheets): *What specific activities, investigations, problems, questions, or tasks will students be working on during the lesson?*

Engage – (10 min)

- Define hōʻike. What does that mean to you?
- Reflection: "I use to think, but now I know…."
- Handout testing worksheet Testing the Prototype

Testing the Prototype

WHAT is a prototype?
Testing is an iterative mode in which we place our low-resolution artifacts in the appropriate context of the user's life. In regards to our team's solution, we should always prototype as if we know we're right, but test as if we know we're wrong—testing is the chance to refine our solutions and make them better.
WHY we test!

1. To refine our prototypes and solutions. Testing informs the next iterations of prototypes. Sometimes this means going back to the drawing board.

2. To learn more about our user. Testing is another opportunity to build empathy through observation and engagement—it often yields unexpected insights.
3. To refine our POV. Sometimes testing reveals that not only did we not get the solution right, but also that we have failed to frame the problem correctly.

Explore – (10 min)

- Setup greenhouse and prepare space for meeting.

Explain – (10 min)

- Present prototype.

Elaborate – (20 min)

- Engage in conversation and gather feedback from users.
- Record answers on testing worksheet. Students must engage users in discussion and answer the following questions during the testing session.
- Assign final unit test (online).

STEP 1
Site Selection:

1. Who needs to be there?
2. What does the space need to be like?
3. Time of day/ specific weather needed for effective testing?
4. Length of time for testing?

STEP 2
Feedback/recording findings:

1. How will you solicit feedback?
2. How will you record feedback?
3. How will you record results?

STEP 3
Test:

1. How will you run the test?
2. What materials will you need?
3. Who needs to be there? (from your team/experts etc...)
4. Other logistics to think about?

Share Findings:

1. How well did your test work?
2. Would you change anything about the test if you had a chance to do it again?
3. What feedback did you get?
4. How will you move forward with your idea?
5. What advice do you have for others?

Evaluate – (1 day)
Complete guided essay test questions in Design Thinking Notebook online:
1. **Describe your roles as both a CLA community member and participant in our Design Engineering Challenge. Exactly what did you contribute to this project and to the team? Explain.** (i.e., how you demonstrated taking initiative, how you expressed helpfulness)

2. **What do you like about the watering system/design prototype our team created**? Design Thinking is an "iterative" process, meaning that the steps repeat. Prototypes continue to be adjusted and tested. Even the problem

can change as people's needs are better understood. Design Thinking is a human-centered process, and the needs of the user come first.

3. **Currently, what would you change about the current watering system/design prototype our team created? How can our current system be improved?** I am not asking you to suggest an entirely new concept, but to suggest the next phase of improvements for the current system.

4. We must have clear goals that let us know when we have successfully solved the problem. **What clear goals did we have at the beginning of our project? Do you consider our design a success?** Explain.

5. New technologies can have deep impacts on society and the environment. **What meaningful impacts can the watering system we created have on our school community**?

6. Analyzing the costs and benefits of any engineering project is important. **Evaluate each of the potential costs or benefits**:

- The cost(s) (monetary and non-monetary) of NOT having a watering system in the greenhouse:
- The cost(s) (monetary and non-monetary) of building a watering system in the greenhouse:

- The benefit(s) of building a watering system in the greenhouse:
- The benefits of using the Design Thinking Process in building the watering system:

Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

7. **Write about a NEW and meaningful problem (not related to greenhouse irrigation or our watering system) in or near our CLA school community that can be solved using Design Thinking?** This problem can be big or small and can relate to the natural environment, man-made environment, learning environment, social environment, or surrounding communities in Puna or Hilo. Make sure to choose a problem that is realistic, can be clearly defined, and can be "solved" using the Design Thinking process. (5-sentences min.)

8. **Based on the problem mentioned in #7, identify a person or community group ("the user") you could interview to help understand this problem better. Who is it (name or role) and what are their qualifications to speak about this problem**?

- **Who**:
- **Qualification**:

9. **Define the problem from #7 by writing a POV statement based on the need of the user.** This problem should be the focus of your new engineering design challenge. (Be specific and detailed in this answer.)

- **Define the problem with a POV statement (2-sentences min.)**:

10. For #7-9, you EMPATHIZED and DEFINED a new problem that you feel is worth paying attention to. Now, think carefully about your answers to #7-9 above. **Describe what steps are involved in the next phases of the Design Thinking process in designing a solution to the problem.**

Ideate	

Prototype	
Test	

11. Solving complex, real-world problems can be a messy process and we don't always know what the correct answer is. These types of "ill-defined, wicked" problems are common in the fields of design and engineering. **Did our Greenhouse Engineering Design Challenge count as a "wicked" problem?** Explain.

12. Complex, real-world problems can be solved by breaking them down into smaller more manageable design challenges that can be solved through engineering. **Explain how our school's greenhouse watering system is connected to the larger issue of freshwater resource conservation. (5-sentence min.)**

Evidence of Success: Turn in all work accurately and completely, demonstrate their ability to meet learning objectives, answer guiding questions either verbally or in written form. Students pass test.

Students interacted with the product users in a professional and meaningful way. They were able to collect feedback for how to improve for future iterations of the design. Students were respectful and genuinely concerned that the user's needs were met in the context of the design engineering challenge.

Notes and Nuances: *Vocabulary, connections, common mistakes, typical misconceptions, etc.*

Vocabulary: STEMS^2, hōʻike, authentic user/ authentic testing, design thinking

Materials/Resources:
Design Thinking Notebook
Laptops with internet access
Unit Test

Homework: Complete guided essay test questions in Design Thinking Notebook online.

Lesson Reflections:
- What do I want students to know about testing their prototype?
- What do I want students to take away from the design engineering process?
- Why is it important that students understand the process and mindsets of design thinking?
- What role does creative thinking have in my classroom?
- Was I effectively able to incorporate the following mindsets in this unit plan?
    - empathize through the 3Ps (time period, place, people) via place-based, community-based partnerships
    - seek to understand the practices of design thinking/STEMS2 across various cultures and settings, including ancient, traditional and modern contexts
    - embrace multiple lenses by engaging in authentic, hands-on investigation, problem solving and community service

- craft culturally respectful and place-appropriate solutions that are both equitable and empowering for the community/culture you are working in
- focus on both the long-term and short-term processes that define culture and spur innovation

Design STEMS2 Mindsets and Practices:
1. empathize through the 3Ps (time period, place, people) via place-based, community-based partnerships
2. seek to understand the practices of design thinking/STEMS2 across various cultures and settings, including ancient, traditional and modern contexts
3. embrace multiple lenses by engaging in authentic, hands-on investigation, problem solving and community service
4. craft culturally respectful and place-appropriate solutions that are both equitable and empowering for the community/culture you are working in
5. focus on both the long-term and short-term processes that define culture and spur innovation

More Background:

New designs often have unexpected problems, and it is often difficult to determine whether a new design or product will perform as intended. Prior to large-scale manufacturing of a product, engineers often build prototypes. A prototype is a model of a product used to explore design alternatives, test theories, confirm performance and ensure the product is safe and user-friendly. Engineers use prototypes to figure out specific unknowns still present in the design.

For example, a student team designing a prosthetic hand that rolls dice could build a prototype using simple materials such as wood, rubber bands and string to test that the prosthetic hand performs the desired function of rolling and picking up dice. In most cases, an iterative series of prototypes is designed, constructed and tested as the final design emerges, is refined and becomes ready for production.

A philosophy often repeated and credited to Tom Kelley of IDEO, a successful worldwide engineering design and innovation consulting firm, is, "Fail often to succeed sooner." It might be helpful for students in the midst of prototyping iterations to see the value of this approach as expressed by professional designers. We learn more from failures than successes.

Rapid prototype machines can literally bring computer-aided engineering designs to life! Some examples of objects, tools and parts manufactured using a rapid prototype machine and CAD software.

Often, the term prototype is interchanged with the term "model," which can cause confusion. While several types of prototypes exist, for the purpose of this activity, we will make the following distinction: Whereas a model is used to demonstrate or explain how a product will look or function, a prototype is used to work out the kinks in a design or to try new ideas. Keep in mind that prototypes are unrefined versions of a future product. Most companies do not show prototypes to the general public to ensure that the public's opinion is based on the final product.

In some cases, engineers "rapid prototype" a part. Rapid prototyping is the automatic construction of physical objects using additive manufacturing technology and computer-aided design (CAD) software.

Basically, a virtual design from CAD software is "read" by a rapid prototyping machine that divides the design into thin horizontal slices. The machine then lays down successive horizontal layers of liquid or powder (such as ABS plastic material) and adhesive in the shape of the virtual design. The primary advantage of rapid prototyping is the ability to create almost any shape or feature, including assemblies with moving parts.

