Photo by Kanu Hawai'i

Standard Benchmarks and Values

CCSS

- **8.G.9**– Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.
- **Math.Practice.MP1** – Make sense of the problems and persevere to solve them.
- **Math.Practice.MP5** – Utilize appropriate tools strategically.
- **ELA-LITERACY.WHST.9-10.9** – Drawing evidence from informational texts to support analysis, reflection, and research.
- **SL.11-12.4** – Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

NGSS

- **MS-ETS1-2**– Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.
- **Science & Engineering Practice 7** – Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

NHMO

- #3 ʻIke Mauli Lāhui (Cultural Identity Pathway)
- #6 ʻIke Naʻauao (Intellectual Pathway)
- #7 ʻIke Hoʻokō (Applied Achievement Pathway)
- #9 ʻIke Kuanaʻike (Worldview Pathway)

GLO

- Community Contributor
- Complex Thinker
- Quality Producer
- Effective and Ethical User of Technology

A SPLASH OF STEM THROUGH AQUAPONICS

Yuko Iio

6-8 (including Special Education)
At least five 45- to 60-minute class sessions

How do we select appropriate strategies, methods, and resources to solve problems and thus become good problem-solvers?

Enduring Understandings

Students will understand that...

- Problem-solvers apply a variety of strategies and methods and consult only valid resources to solve a given problem;
- Connections exist between mathematics and every academic subject as well as real-world situations.

Critical Skills and Concepts

By the end of the unit, students will be able to...

- explain to a new audience how an aquaponics system works;
- mitigate problems and choose solutions appropriate to the given situation;
- acquire useful information from valid electronic resources;
- create their own aquaponics diagram that includes all essential materials and illustrates how these each function.

LESSON

Authentic Performance Task

- Creating an aquaponics system using provided materials by working together in groups, sharing ideas and information gathered from the different resources and applying unique strategies and methods to devise solutions;
- Explaining how mathematics is used in designing and building an aquaponics system and how mathematics can be used in other similar design contexts.

Authentic Audience

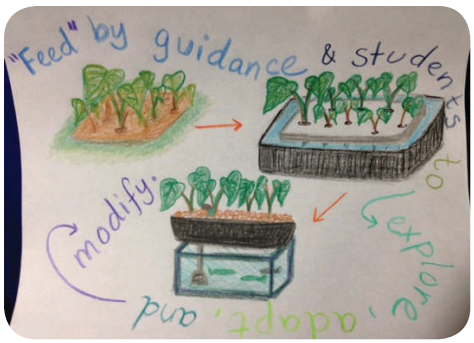
Family members, community, and anyone interested in aquaponics.

Other Evidence

- Observed classroom behavior and level of cooperative rapport established between students (e.g., sharing ideas with peers without negative comments).
- Ability to recall the procedural sequence for building an aquaponics system.
- Ability to identify appropriate resources from valid sources.
- Ability to design their own aquaponics system using materials other than those provided.
- Performance on Common Formative Assessments (CFAs) after each lesson (given as 1- to 2-question bell work or exit passes), to ensure clarity of understanding of each task before going on to the next.

Background & Purpose

The indigenous people of the Hawaiian Islands traditionally used and continue to use aquaculture to cultivate fish and plants for consumption. Loko iʻa (fishponds) were engineered using resources from both land and sea (e.g., to build their surrounding kuapā or walls) and, in some cases, by using pre-existing natural formations. As places where kai (ocean water) meet wai (freshwater), loko iʻa provide nutrient-rich environments for both plants and fish to congregate for easy (though conservative) harvesting. Having productive, well-maintained loko iʻa allowed the people of that ahupuaʻa (traditional mountain-to-sea land division) to live sustainably and healthily.



Despite the increasingly urbanized landscape of modern Hawaiʻi, aquaponic systems represent a highly adaptable, efficient, and affordable means by which to independently grow fresh vegetables and fish. By becoming familiar with aquaculture through aquaponics, students will ideally be able to not only perpetuate a clean (i.e., fossil-fuel-free) means by which to cultivate edible resources but also gain confidence in their abilities to come up with productive and pono solutions for the benefit of their communities.

Lesson Plan One

Lesson One 2 - 3 Days

LESSON

Rationale

- Identify valid information on the Internet or other resources.
- Understand that not all information given through the Internet is valid.

Learning Outcome

- Ability to use a variety of resources to gather information pertaining to aquaponics.

Prerequisite Skills and Concepts

- Some familiarity with Internet searches (e.g., using web browsers) and other resources.

Materials and Resources

- Internet, books, magazines, articles in journals.
- Elmo or Promethean/smart board.

Learning Activities

Teacher Activities	Student Activities	Duration
Introduction: • Written on the board, what is aquaponics? • Teacher will discuss to the students as a whole class that they will be doing a project on aquaponics system. For the project, students will research the process and how aquaponics work. The students have a choice on their finished project such as creating a song, poem, story, illustrations, constructing a model, creating a brochure or commercial, or interviewing a person that has their own aquaponics. • Teacher will tell the students to go research what is aquaponics using any research tools.	• Students ask questions about the project.	10 min.
Body: • Teacher will assist students who are having a difficulty with finding the resources. • Teacher will print out any information students researched through the internet. This will be done during the class period while the students are researching. • Teacher then assists each student with their chosen project. Discuss individually with students to get them on the right track to start their project.	• Students will find resources to research the topic. Students will identify valid information from different sources. • Students choose which choice they will go with for the project once they've gathered the information needed. • After student has discussed with teacher, they will start creating their project.	1 hour 1 hour

Teacher Activities	Student Activities	Duration
Closure: • Teacher will have one day to have students present the project.	• Students will present their projects referring to sources they used to do the project. They should be able to validate how or why they think that source they used was a viable choice.	45 min. (Depending on how many students are in the class period and how long each student presents)
• Teacher to facilitate students to ask questions to the presenter.		10 min.
• Discuss with the students what they learned about Hawaiian aquaculture. During this time, teacher will share with students the cultural background of aquaculture in Hawai'i, showing visuals of loko i'a, fishponds.	• Student will discuss personal experiences with aquaculture.	

Assessment

Criterion	Exceeds 4 points	Meets 3 points	Approaching 2 points	Below 1 point
Use of resources	Uses common and unique resources to find information.	Uses common and unique resources to find information.	Uses common and unique resources to find information.	Uses only resources that are readily available.

Lesson 2

1 - 2 Days

Rationale

- Provide an opportunity to recall information from the previous lesson and apply it, using the given materials to create an aquaponics system.
- Ability to discuss with peers and formulate a plan to create an aquaponics system (for the next lesson).
- Understand that problem solvers apply a variety of strategies and methods to solve a given situation.

Learning Outcome

- Ability to present ideas and construct convincing arguments supported by evidence from prior learning (i.e., during previous lessons).

Prerequisite Skills and Concepts

- Basics of the process of aquaponics including what materials are needed to create one.

LESSON

Materials and Resources

(Purchased place and price without tax)

5 gallon water bottle
(Walmart, $8.18)

Black volcanic cinder ¾ cu ft.
(City Mill, $5.29) or any grow media

12 ounce water bottle
(Recycled, free)

5 Comet (Petco, $0.19 each), use a paper cutout of a fish for the second lesson. Do not purchase the fish until the day of the second lesson.

Goldfish-Comet food
(Petco, 1.02 oz. $4.99)

2 Scouring Pads Heavy Duty Green (City Mill , $2.49 each)

80 GPH Aquarium Submersible Water Pump (Amazon.com, $13.98 w/ shipping) or any pump made for small water fountains

PVC Schedule 40 ¾ x 24'
(City Mill, $1.89) or tubing
Depending on your pump, you would have to find a PVC pipe or tubing that will fit the opening of the pump.

Plant or seedling (Manoa lettuce plant starters, $1.59 each) Buy the plant the day before the last lesson. Seeds can be bought at any time.

Water	Float the bag with the goldfish in the water for about 30 minutes and then transfer the fish and the water in the plastic bag into the bottle.

Tools Needed

Drill, Double-edged pull saw, and Sandpaper.

PREPARATION

Preparation Time Total: Approximately 45 min.

Teacher Preparation Steps	Pictures	Duration
• Teacher will prepare the lesson materials.	• Preparation was done outside of school away out of sight from the students.	
• You will need a double-edged pull saw or any saw to cut through the water bottle.		
• Cut through the plastic 5 gallon water bottle using the saw. Find a line you can follow on the bottle. If you need assistance, use a carpenter tape to make a perfect straight cut around the bottle. Cut just the top section off, which will end up as the plant media bed after it is flipped over into the bottle.		5 min.
• After sawing the bottle, sand the edges using sandpaper to soften the ends.	 	10 min.
• Drill holes on the growing bed so the water can go through after the water is pumped.		5 min.

Learning Activities

Teacher Activities	Student Activities	Duration
Introduction • Using just and all of these materials provided (place the materials on a table where everyone can easily see the materials and only the materials), students will create their own design of what they think aquaponics would look like. Students will be reminded to think back about what we learned so far from our research of how aquaponics work.	• Students are listening to the teacher and observing the materials on the table. Using their prior knowledge, thinking about how to put it together.	5 min.
Body • Teacher gives students a sheet of paper. • Depending on the students, they can work individually or with a partner. • They will be given 20 -30 minutes to work on it and then have a whole class discussion.	• Students will use a sheet of paper to illustrate how it would look utilizing the materials. They are able to go to the table and touch the materials. • Students will discuss and draw their creation referring back to the given materials.	20-30 min.
Closure • Teacher will facilitate the discussion while questioning the students why they came up with the idea. • Teacher will listen to the plan and facilitate when students come up with a solution that seems to not work. Teacher will not directly given them the answer, but give scenarios which will hopefully lead the students to understand that it will not work.	• During the whole class discussion, students will briefly present what they came up with. • Students will tweak the ideas from adding things from different students to come up with one plan on creating an aquaponics that work with the given material.	20 min.

Assessment

This will be a formative assessment to gather the understanding of aquaponics and working as a group to problem solve. Also for students to be able to construct an argument using gathered evidence from the previous lesson.

Criterion	Exceeds 4 points	Meets 3 points	Approaching 2 points	Below 1 point
Problem Solving	Actively seeks and suggests solutions to problems.	Improves on solutions suggested by other group members.	Does not offer solutions, but is willing to try solutions suggested by other group members.	Does not try to solve problems or help others solve problems.
Research and Information Sharing	Gathers information and shares useful ideas for discussions. All information fits the group's goals	Usually provides useful information and ideas for discussion.	Sometimes provides useful information and ideas for discussion.	Almost never provides useful information or ideas for discussion.

LESSON

Lesson Plan Two

2 - 3 Days

Rationale

- Students will understand that connections are made within different areas of mathematics and between other content disciplines.
- Mathematics is also connected to real world application.

Materials and Resources

- All the materials from lesson 2
- * Teacher to buy the fish for the second day of this lesson. *
- Scissors
- Sharpie
- Bucket
- Sink
- Ruler
- Formula sheet including the volume of a cylinder. (Students usually use their student planner reference sheet or math reference sheet given by the teacher)
- Calculator
- Fine tip pen
- Measuring cup

Learning Activities

Teacher Do	Student Do	Duration
First Day Introduction: • Teacher will break the class into groups of no larger than 5 and have them create the aquaponics system using the materials. • Teacher will observe the students put together the aquaponics system that the students agreed on from the previous lesson. Small group ideas: • If you have a larger class, you may want to have more aquaponics system materials or break the class into groups of no more than 5. If budget is an issue, have one group watch the Olomana Gardens video or any aquaponics video while one group works to put it together up to the part where they put the plant and fish in. They can switch until all of the classes have worked on getting to that step. Once they have all been able to put it together. You can do a whole group finish with adding the fish and plant to complete the lesson. Students watching the video will give you minimal assistance to them while the teacher can facilitate the small group putting together the aquaponics system.	• Students work in groups to figure out what the steps are to get this aquaponic system to work.	Length approximately 45-60 minutes up to the last part of adding the plant and fish. (This is with minimal assistance from the teacher). With a big class, you will need multiple days if you only have one aquaponic system materials. Last part is done on the second day, since you will need to at least 30 minutes to float the fish in the bag over the water.

Teacher Do	Student Do	Duration
• Teacher makes sure the students are suctioning the water pump to the center of the 5 gallon water bottle.	• Student attaches the tubing/ pipe onto the water pump. • Student suctions the water pump to the center bottom of the 5 gallon water bottle.	3-5 min.
	• Student flips the top portion of the 5 gallon water bottle to make a media bed. • Student places the tubing/pipe through the center of the top portion 5 gallon water bottle.	3 min.
• Teacher have scissors ready for students to cut the scouring pad. Assist students to use a sharpie to create a line on the scouring pad so they don't cut too much which may cause the growing media to fall through to the bottom.	 • Student to measure the diameter of the tubing/pipe and create a line using a sharpie towards the center of the scouring pad. Do the same for the second scouring pad by crisscrossing the pads like above. • Cut the two scouring pads and crisscross the scouring pad. • Pull the tubing/pipe through the scouring pad.	8-10 min.
• Poke holes using a fine tip pen around the top portion of the 12 ounce water bottle. Poke about 6-8 holes. • If you have students that are able to do this without stabbing themselves with the pen, have them do it. Model the first hole before letting your students do it.	• Have students observe or participate in this step by using a sharpie to write a dot approximately equal distance from dot.	5 min.
• If the tubing/pipe mouth is too small for the opening of the 12 ounce bottle, use rubber band(s) to close the gap.	• Student place the 12 ounce bottle upside down and fit it onto the tubing/pipe.	2-5 min.
• Teacher has the volcanic cinder ready by cutting a small portion at the corner of the bag.	 • *Student will pour the volcanic cinder into a bowl.	3 min.

Teacher Do	Student Do	Duration
• Teacher model how to wash and rinse the cinder.	 • *Student will take the bowl with cinder to the sink.	5 min.
	• *Student will wash the volcanic cinder until the color of the water lightens. Wash and rinse the cinder approximately 5 or 6 times.	
	 • Have students place the volcanic cinder into the growing bed. Repeat the prior steps (marked with a *) until the growing bed is two-thirds filled.	Depends on how much the students pour into the bowl at each time. Approximately 5-10 minutes.
• This math step if for students to understand the concept of finding a volume and applying it using a hands-on activity. • Teacher starts a discussion about what formula to use to find out how much water to place into this bottle. Students may respond by saying to find the area. This will be a good opportunity to discuss the difference between an area and volume. Which one will be appropriate to use in this situation. • Before finding the volume of the 5 gallon water bottle where the fish will be placed. Discuss with the group how much water to put in. If students are unsure, use your fingers starting from the top of the bottle. Teacher Formula Reference: • Volume of a Cylinder V = πr ^2 h π≈3.14 or 22/(7) r^2= radius ×2 h = height of the cylinder	• Students should start discussing that they can't fill the whole bottom portion of the bottle because the water will overflow. Also, they should keep in mind that the growing bed should not be touching the water level. • Determine as a group what shape this bottle is, so they can figure out which formula to use. • Once they have figured out they need to find the volume of a cylinder, students can discuss as a group to where they want their height to be for measuring how much water to place into the bottle. • Measure the volume of the bottom portion of the 5 gallon water bottle referring to their volume formula for a cylindrical figure. Students should use the estimation method by either estimating the π to 3 or the solution into a whole number.	10 - 15 min.

Teacher Do	Student Do	Duration
• Teacher finds a place in the classroom where you would like to leave the aquaponics system when it is complete. It's best to place it by a window and an access to the outlet for the water pump. • Teacher starts the water pump and keeps it running overnight.	• Students pour the amount of water from the sink using a measuring cup.	5 min.
Second Day Teacher Preparation: • Teacher will float the bag with the fish in the water for about 30 minutes in a bucket full of water. • *Note: If you use a comet (cheapest fish), they like to be in cold water.	 • Student can transfer the fish and the water in the plastic bag into the bottle.	30 min. of teacher preparation and 3 min. of student preparation
• Teacher models taking the plants out from the container in which it came in. • Teacher will model or verbally assist with placement of the plants.	• Student takes the plants out of the container and removes the soil.  • Then, places the plants in the media bed pushing the volcanic cinder to the side to create a hole where the roots can grow. Students will push back the volcanic cinder to support the plants.	5-8 min.

FINAL PRODUCT

Assessment

Criterion	Exceeds 4 points	Meets 3 points	Approaching 2 points	Below 1 point
Group work	Works to complete all group goals.	Usually helps to complete group goals.	Occasionally helps to complete group goals.	Does not work well with others and shows no interest in completing group goals.
	Always has a positive attitude about the task(s) and the work of others.	Usually has a positive attitude about the task(s) and the work of others.	Sometimes makes fun of the task(s) or the work of other group members.	Often makes fun of others' work and has a negative attitude.
	All team members contributed equally to the finished project.	Assisted group/ partner in the finished project.	Finished individual task but did not assist group/partner during the project.	Contributed little to the group effort during the project.
	Performed all duties of assigned team role and contributed knowledge, opinions, and skills to share with the team. Always did the assigned work.	Performed nearly all duties of assigned team role and contributed knowledge, opinions, and skills to share with the team. Completed most of the assigned work.	Performed a few duties of assigned team role and contributed a small amount of knowledge, opinions, and skills to share with the team. Completed some of the assigned work.	Did not perform any duties of assigned team role and did not contribute knowledge, opinions or skills to share with the team. Relied on others to do the work.

REFERENCES

- Arthur L. Costa, Developing Minds: A Resource Book for Teaching Thinking (Alexandria: Association for Supervision and Curriculum Development, 1985), 125–37.
- Bernstein, Sylvia. (2011). Aquaponic Gardening: A Step-By-Step Guide to Raising Vegetables and Fish Together.
- Bluelab Corporation. (2013). Aquaponics: Aquaponics is the combination of two food raising methods that both use fresh water. Retrieved on April 13, 2014 from https://www.getbluelab.com/knowledge-base/aquaponics.
- Common Core State Standards. (2014). Retrieved on December 28, 2013 from http://www.corestandards.org/.
- Costa-Pierce, B. 1987. Aquaculture in Ancient Hawaii, Integrated Farming Systems Included Massive Freshwater and Seawater Fish Ponds Retrieved on April 11, 2014 from http://www.jstor.org/discover/10.2307/1310688?uid=3739632&uid=2&uid=4&uid=3739256&sid=21104318420667.
- D'Ambrosio, U. (2001). Ethnomathematics Link between Traditions and Modernity. Amsterdam: Sense Publishers.
- Franker, Karen. (2007). Retrieved on April 11, 2014 from https://www2.uwstout.edu/content/profdev/rubrics/elemteamworkrubric.html.
- Friendly Aquaponics, Inc. (2011) Retrieved on April 10, 2014 from http://www.friendlyaquaponics.com/alternate-energy-on-the-farm/
- Hawaii State Department of Education. (2014). General learner outcomes rubrics. Retrieved on December 28, 2013 from http://doe.k12.hi.us/curriculum/GLO_rubric.htm.
- Luft, Julia. (1997). Science Scope, Florida Retrieved on April 10, 2014 from http://www.specialeducationsupportcenter.org/ trainings/effective_instruction/resources/design-your-own.attachment/attachment/Design_rubrics.pdf.
- Nā Honua Mauli Ola Pathways (2014). Retrieved on March 21, 2014 from http://www.olelo.hawaii.edu/olelo/nhmo.php.
- Oko Farms. (2012). Retrieved on December 27, 2013 from http://www.okofarms.com/consultation-design/.
- Olomana Gardens Permaculture & Aquaponics DVD (2012).
- Szyper, Jim. (1989). Backyard Aquaculture in Hawaii. Windward Community College. Retrieved on January 11, 2014 from http://eco-library.theplanetfixer.org/docs/aquaponics/backyard-aquaculture.pdf.