Effectiveness of an experiential agriculture program with at-risk Hawaiian teens

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Science education problems in Hawaii.

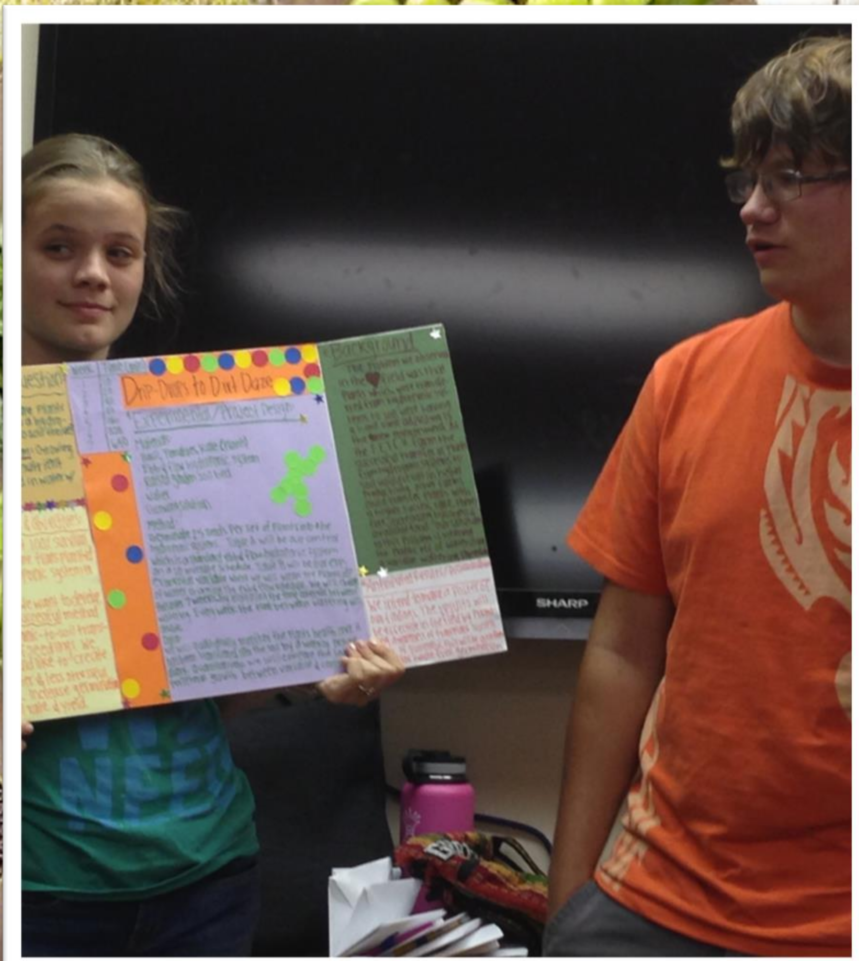
- **Hawaii ranks among the lowest states in science and math standardized test scores at several grade levels**
- **Comparatively few local youth apply for or are admitted into UHM agricultural, or other, science programs**
- **Hawaii students who are admitted are often inadequately prepared for college level science.**
- **High, college drop-out rate**

Hawaii imports 85% of its food.

The "Hawaii State Sustainability Plan 2050" calls for:

- Greater food security, through small-scale local food production,
- Improvements in agricultural infrastructure (land, markets, loans, processing, transport) to enable small-scale farming
- A significant increase in trained agricultural technicians, farmers and agribusiness entrepreneurs

The Hawaii Sustainability plan calls for:



- significantly more Hawaii youth attending college and majoring in the sciences
- adequate science preparation for students at all levels of schooling in Hawaii
- More experiential, holistic and research-oriented science education
- alignment of the science curriculum from elementary through college
- Average or above average student scores on standardized science tests
- Greater sustainability education at all levels of education and for the public
- new curricula that incorporate school gardening with science and other subjects

The "Teen Internship in Sustainable Sciences" addresses these needs.

Program objectives were to produce statistically significant improvements in students':

1) knowledge of life systems (plants, animals, insects, soil micro-organisms)
2) Knowledge of the cellular, molecular and biochemical processes that underlie the life processes of these systems
3) Ability to observe, test and understand the relationships among these systems (e.g., between humans and plants, plants and soil, plants and insects, humans and food sources)

Produce significant improvements in students':

4) Ability to apply background knowledge to formulate and solve real-world problems

5) Scientific habits of mind, familiarity with the scientific method and research, lab and field-science skills

6) Trades skills needed to build and run a farm and to set up experiments (carpentry, irrigation plumbing, field-clearing, horticulture practices, tool use, machine operation)

7) Business skills needed to plan, market, build, manage and profit from a functioning farm

Program Description: College-age mentors and at-risk youth planned, built, managed and marketed a 1/10th acre, CSA farm. After 4 months, they produced baskets for 3-5 families weekly.

Thirty 8th-12th grade students participated, for 5-7 hours/week, across a 2-year period.

Mentors taught a 10-unit agricultural sciences curriculum with hands-on, lab- and field-science activities. Topics were: human nutrition, soil science, botany, plant propagation, composting, plant nutrition, hydroponics, integrated pest management, and CSA farming

Each week, participants moved through 6 activities. They: 1) farmed; 2) harvested & prepared CSA baskets; 3) cooked a farm meal using recipes from a specific culture; 4) attended a conceptual lecture; 5) did a lab and field-science activity; and 6) ate dinner and discussed the day in their mentoring groups.

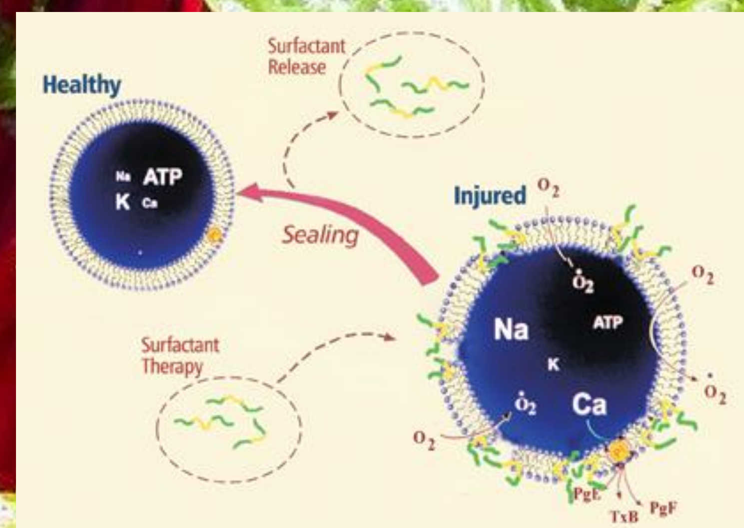
Each mentoring group managed one segment of the farm; produced a basket per week from it; and conducted and presented a group research project.

We developed the curriculum: "Organic Farming with Youth"

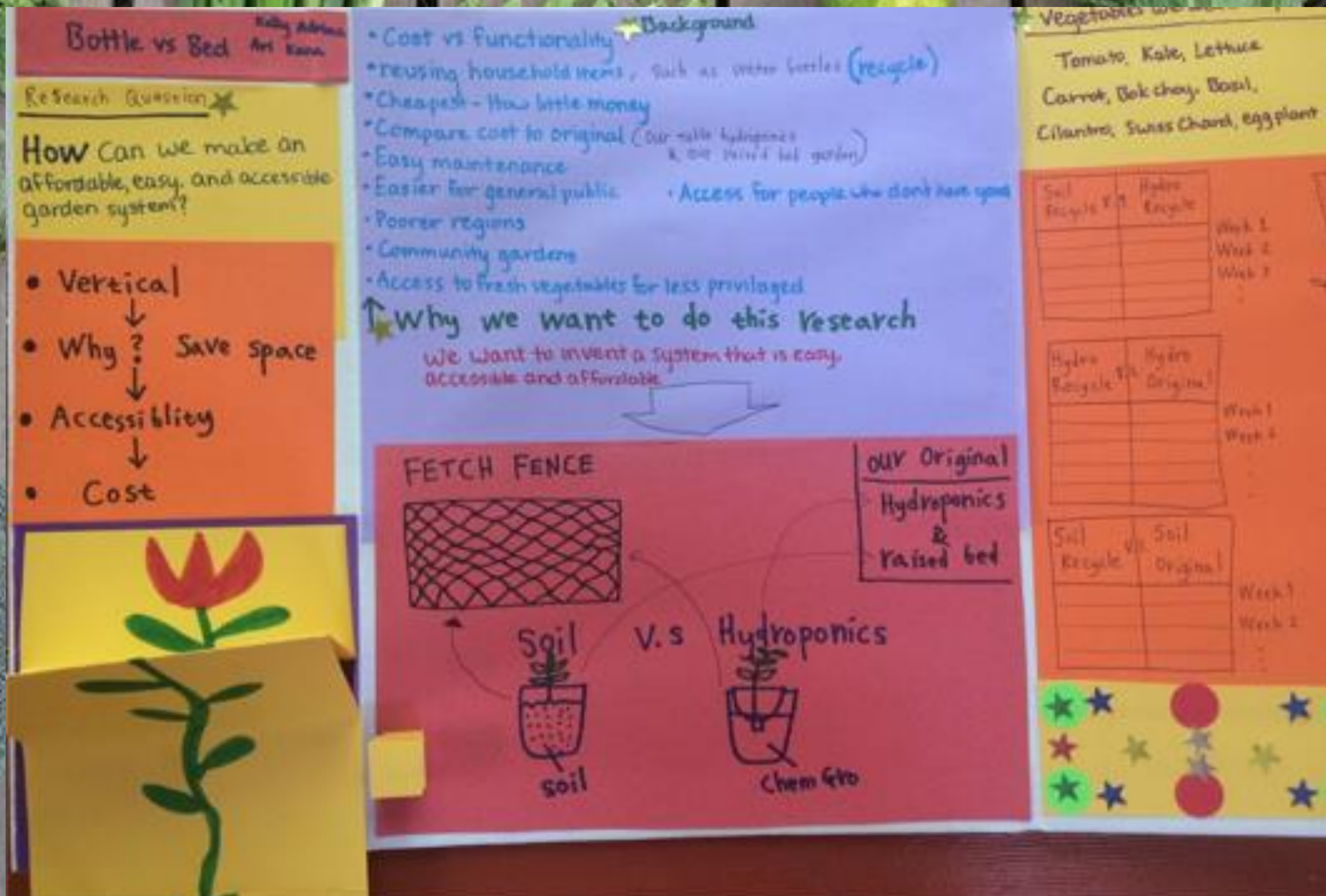
- Three functions:
- 1) A step-by-step manual on how to build, manage, market and research a small, organic farm
- Motto: "1/10th acre + 10 youth=food for 5 families"
- 2) Explain foundational bio-science in depth, but within a holistic, real world context
- 3) Expose students to lab-, field-science and research methods with activities that call on youth to use conceptual knowledge to solve problems on their farm

Unit 1. Why do organic farming?

- What nutrients (foundational chemicals) do humans need?
- What are the nutrients used for at the cellular level?
- What happens if nutrients are not available for these processes?
- What foods provide these?
- Where do we get our food?
- How reliable is our food source?
- Why might we want to provide our own food?
- How can we do so through home gardening and CSA farming?

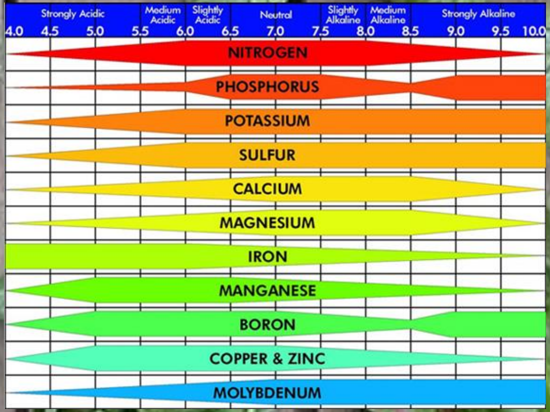


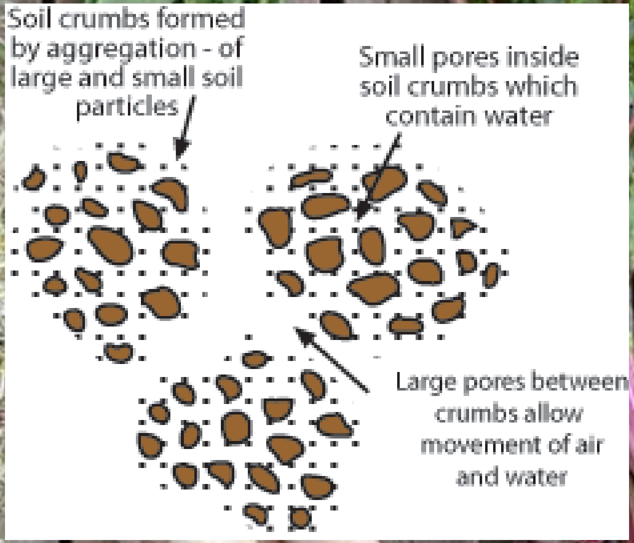
Student project: Compare the cost and effectiveness of two growing systems for homeless shelters: vertical/recycled bottle-pots vs. hydroponics/raised bed



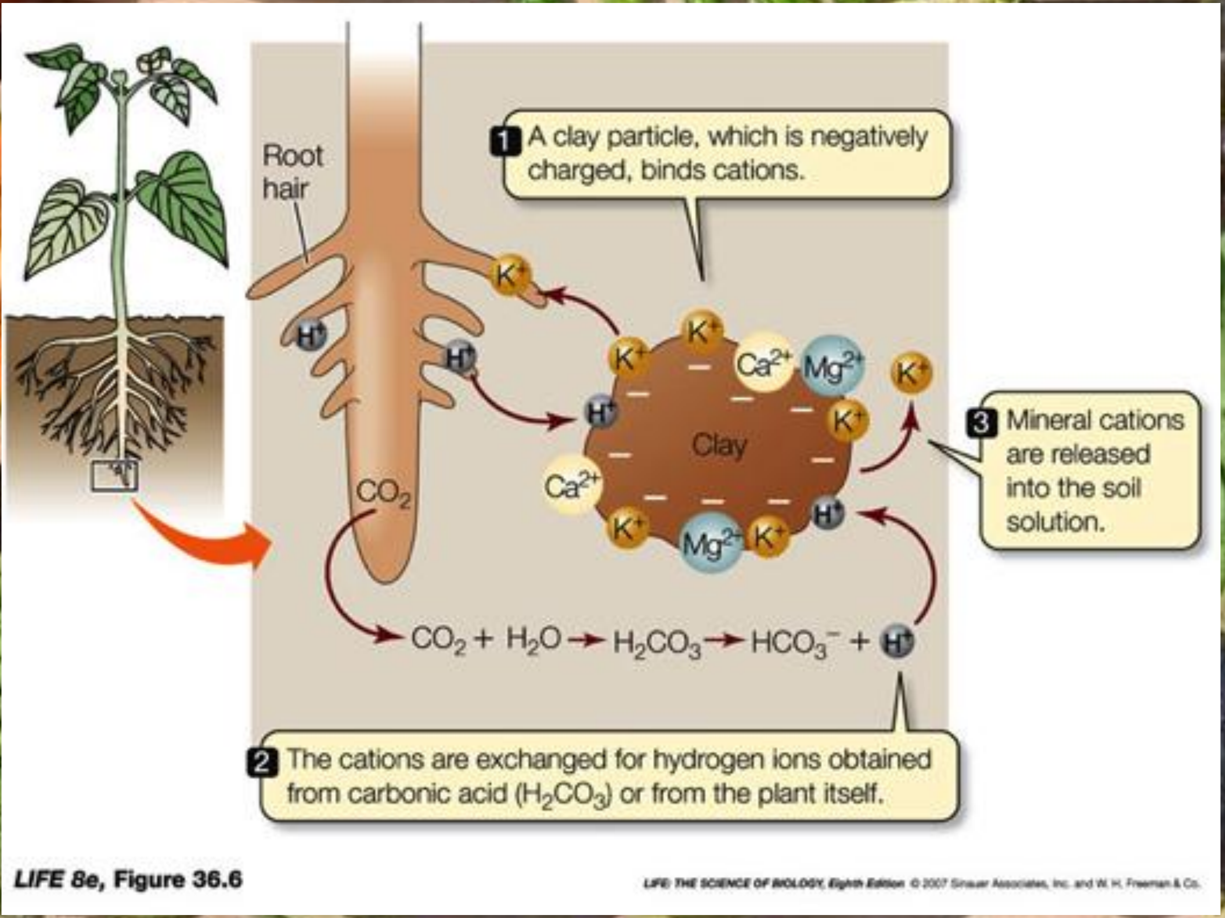
Unit 2: Soil Science: Preparing the fields

- What nutrients do plants need? (C, O, H, N, K, micronutrients, etc.)
- How do plants take in nutrients at a cellular and molecular level?(only solute ions can be taken in)
- What conditions are needed in the soil to enable plants to take in nutrients? (pH at optimal level for minerals to dissolve)
- Why is it important for water and dissolved nutrients to remain in close proximity to plant rootlets? (to enable exchange of ions)
- What can we do to produce adequate conditions? (regulate the pH; improve the crumb structure of the soil; increase the supply of minerals)

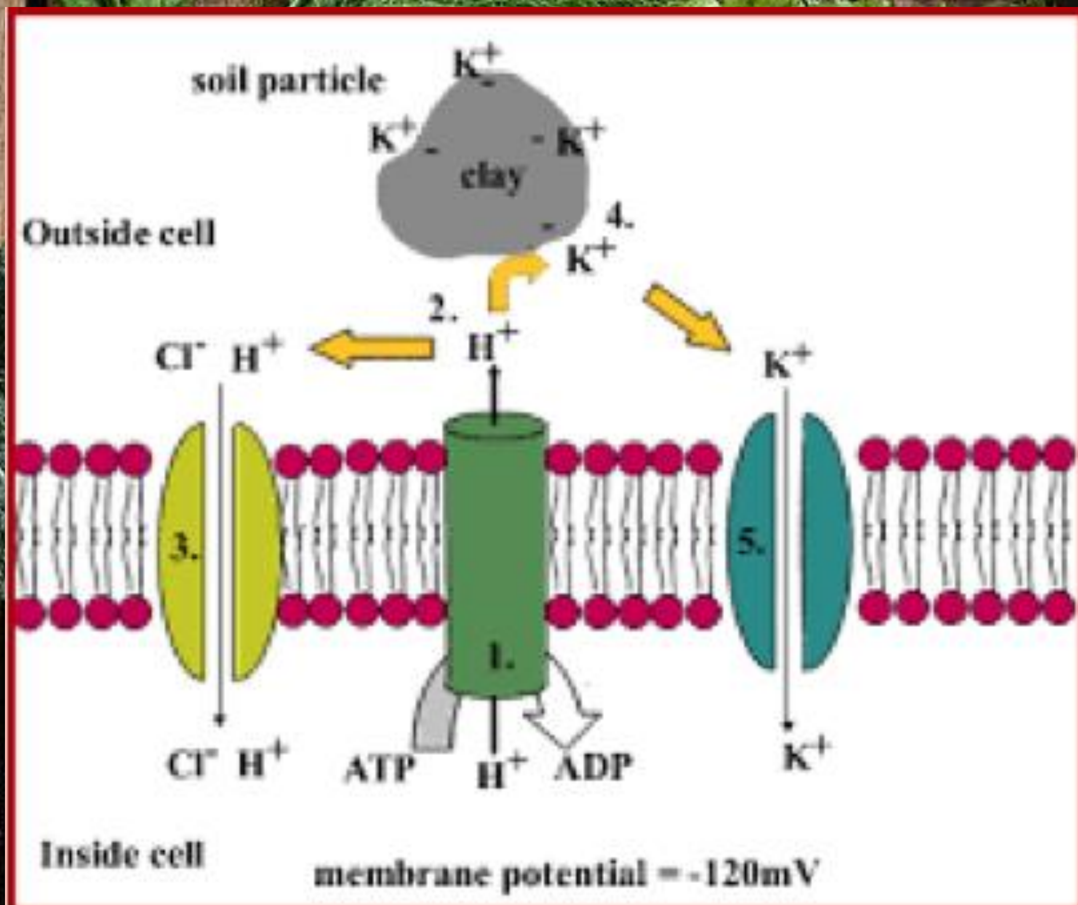




To explain chemical bonding, we show how a H+ ion from the rootlet "knocks" a K+ cation off the negatively charged clay particle. It displaces the K+ cation, taking its place. This "frees" the K+ cation to dissolve in the soil water and be accessible to enter into the plant



Then, we provide more detail, e.g.: a H+ ion displaces a K+ cation on the surface of the negatively charged clay particle—The H+ repels the K+ off the clay, and the released K+ cation can then be taken into the rootlet cell through the protein gate #5



Testing the soil for minerals and pH.

Amending the soil: correcting the soil structure with humus

Unit 3: Planning and Planting: Botany for farmers

- How do plants grow and reproduce?
- What nutrients do they need to survive and thrive?
- What do these nutrients do at a cellular and molecular level?
- How do plants uptake building block nutrients from the environment?
- How do they produce their own food? (photosynthesis)
- How do they reproduce?
- How can we propagate plants?

Studying and drawing plant structures under the microscope

Planting seeds in both hydroponic and soil grow-beds.

Testing soil minerals and pH in both experimental plots

Measuring plant growth in hydroponic vs. soil gardens

Unit 3 (cont). Botany for Farmers

- What environmental conditions do plants need in order to survive/thrive?
- What are common environmental risks? (lack of nutrients, water; temperature extremes; wind; physical damage; pests; diseases, etc.)
- How can we reduce these risks?
- What are best practices in organic farming?
- How can we do research on these?

Unit 4: The role of water in plant growth

- What is the chemical structure of water?
- What are its properties?
- How do these enable chemical bonding and the dissolving of nutrients in water?
- Why is chemical bonding needed for plants to take in nutrients?
- How can we assure that water molecules remain in close proximity to plant roots?
- What are best practices in soil preparation and irrigation?
- How can we research water's role in growth?

Student project proposal on how to acclimate hydroponics seedlings to being transplanted into soil

Unit 5: Composting and its functions

- What is compost? (decomposed organic materials)
- Why is it needed in the soil? (provides organic elements: C O H N; builds soil that has physically optimal pore spaces that enable plants to uptake available nutrients)
- How does composting work?
- What are best practices in the use of compost?
- How can we conduct research on composting?

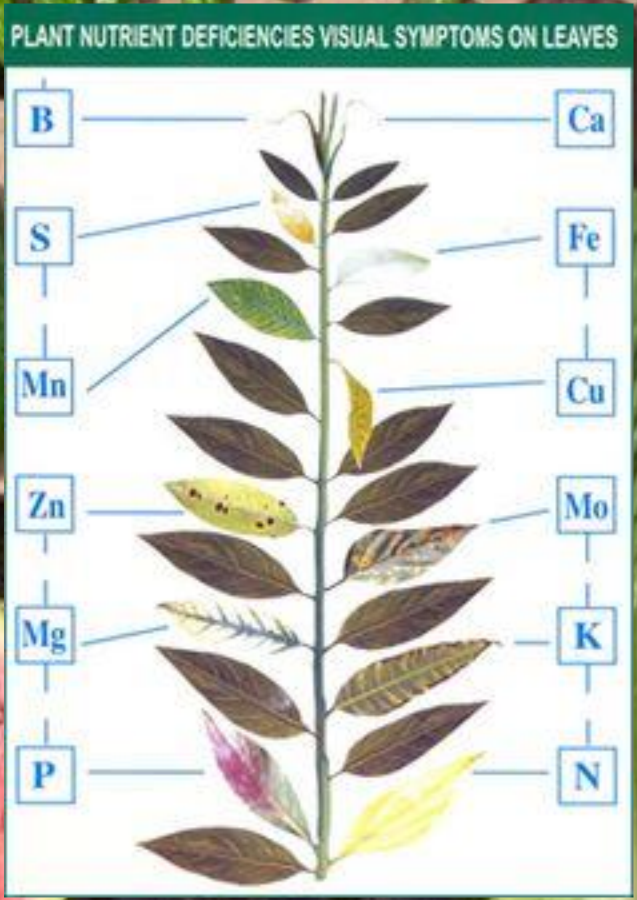
Vermicasting: making worm bins

Unit 6. Plant nutrient deficiencies

- What nutrients do plants need in order to survive, grow, and reproduce? (C, O, H, N and micronutrients)
- What molecule types do plants need? (carbohydrates, lipids, proteins, nucleic acids)
- How do plants obtain nutrients from the soil? (solute ions enter through the cell membranes of the rootlets)
- What environmental factors affect nutrient uptake? (soil pH, soil composition, minerals present, water present)
- What are best practices in plant nutrition?
- How can we experiment with these?

Plant nutrient deficiencies

- What happens when plants fail to uptake needed nutrients?
- How can we diagnose plant nutrient deficiencies?
- What are best practices in remedying these?
- How can we conduct research on plant nutrition?



Unit 7: How can we grow plants in water?

- How can plants grow in the absence of soil?
- Why grow plants in water vs. soil?
- What nutrients do plants need from the water substrate?
- How are these provided in a hydroponics system?
- What Chem-Gro chemicals are dissolved in the water?

Hydro- and Aquaponics

- How are nutrients produced in an aquaponics system? (nitrification cycle produces nitrate and ammonium ion)
- What are optimal conditions for growing in water?
- Best practices: How can we produce optimal conditions?
- How can we study practices and processes of growing in water?

Unit 8: Integrated Pest Management

- What harmful and beneficial organisms are common in Hawaii?
- How are pests classified in terms of HOW they damage plants (chew leaves, drink sap, bore, form galls, eat fruits…)
- How can we optimize plant health to defend against pests?
- How can we organically remove or destroy pests?
- What are common plant diseases in Hawaii?
- How can we prevent and cure these?

Student Project Comparing Different Slug Barriers

Unit 9. Harvesting and Distributing CSA Baskets

- How can we pack CSA baskets to provide a family's weekly vegetable requirements?
- How can we recruit subscribers?

Sorting vegetables by nutrient content

Unit 9: Farm to Fork
How can we encourage more nutritious eating?

- What are psychological aspects of food preferences? (novelty vs. familiarity, etc.)
- Where did different vegetables originate?
- How did they move around the world?
- What are different cultural ways of processing food?
- Why is diversity of food intake optimal?
- How can we introduce cultural variety in food opportunities for children and all family members?

Cooking ethnic foods that are familiar to youth in Hawaii

Pizzas that contain all the daily vegetable requirements as per USDA

Preparing and eating foods from 12 different regions of the world

1. Bedouin nomads; 2. The ancient near east; 3. the Indian subcontinent; 4. Ancient Greece and Rome; 5. The far east: China; 6. Korea; 7. Japan; 8. Southeast Asia; 9. The Pacific Islands; 10. Medieval Europe; 11. The Mongolian Empire; 12. The New World: Central, South and North America.

Learning the history of and enjoying diverse foods

Unit 10: Documenting our products and progress

- Review of scientific method.
- Presenting our research products.
- Presenting our business products.

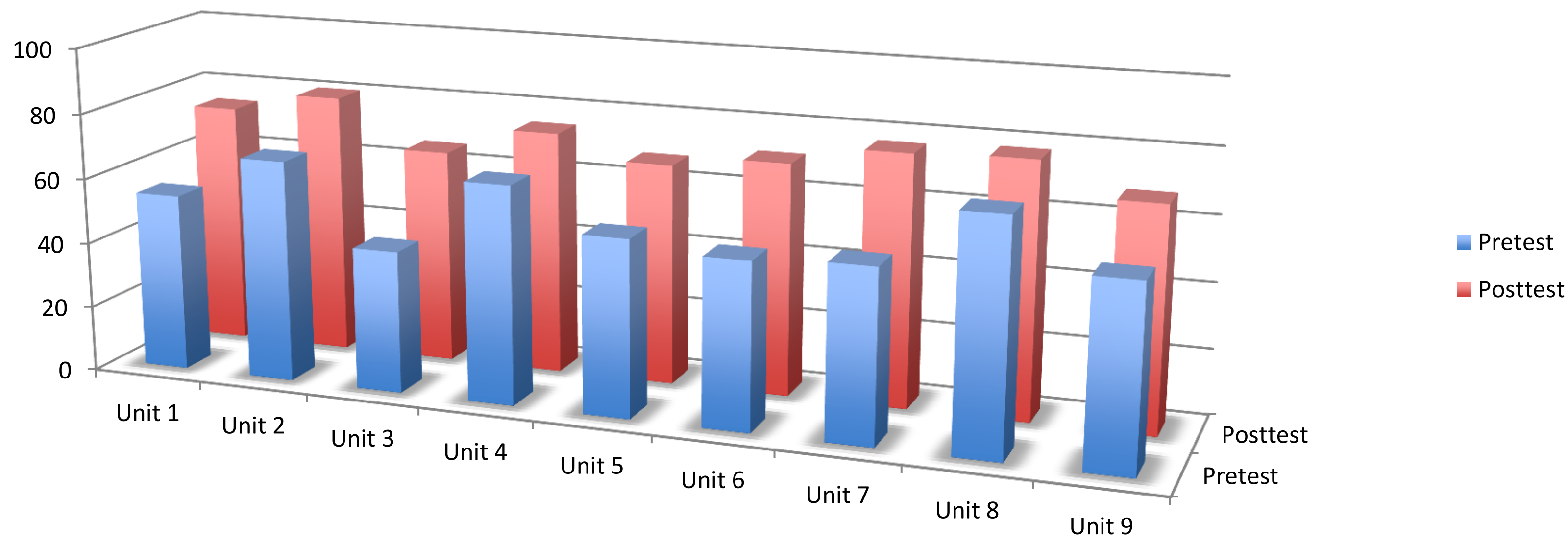
Working in mentoring groups on research proposal

Evaluation: How well does the program address state needs?

- Do students learn foundational processes and structures of plant growth and needed conditions?
- Does the program prepare teens for the content and process of college science?
- Does it address Hawaii state DOE science learning standards?
- Do students develop problem-solving capabilities (the ability to apply foundational knowledge to formulate and solve real world problems?
- Do students learn trades- and business-skills needed to grow food?
- Do students show changes in life-style and psychological approach?
- Do students develop research skills needed to understand and improve agricultural processes?

Do the students learn the material?

Figure 1. Evaluation of pre- and post-test scores for units 1-9 from Fall 2012 to Spring 2014 semesters



	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9
Pretest	54.33	67.83	43.42	66.58	53.92	50.83	52.5	70.33	55.5
Posttest	74.33	80.25	65.75	74.42	67.5	70.83	76.67	77.67	67.92
p-value	0.01	0.01	0.001	0.01	0.001	0.01	0.001	0.02	0.01

Are students exposed to science content they'll confront in college?

Table 1: Curriculum units that introduce content covered in University of Hawaii foundational and agricultural science courses

Course number	Course title	1 Human nutrition & CSA	2 Preparing the soil	3 Botany and planting out	4 The role of water in growth	5 Science of composting	6 hydroponics	7 aquaponics	8 plant nutrient requirements	9 Integratd Pest Management	10 Research & business prodcts	
FSHN 185	The science of human nutrition	x									x	
FSHN 141	Culture and cuisine	x	x	x	x	x	x	x	x	x	x	
BIOL 171	Introductory biology	x	x	x	x	x	x	x	x	x		
BOT 101	General botany	x	x	x	x		x	x	x			
CHEM 161	General chemistry	x	x	x	x	x	x	x	x	x		
PHYS 151	College physics											
TPSS 120A	Plants for People: Hawaii vegetables	x		x			x	x	x			
TPSS 120B	Hawaii beverage plants	x		x								
TPSS 120C	Hawaii herbs, spices	x		x			x	x				
TPSS 120D	Hawaii tropical fruits	x		x								
TPSS 342	Agribusiness decision making tools	x		x							x	
TPSS 200	Introduction to plant science		x	x	x	x	x	x	x	x		
TPSS 304	Fundamentals of soil science		x						x		x	
TPSS 220	Organic food crop production		x	x	x	x	x	x	x	x	x	
TPSS 364	Horticultural practices			x	x	x	x	x	x	x	x	
TPSS 402	Vegetable crop production			x	x	x	x	x	x	x	x	
TPSS 403	Tropical fruit production			x							x	
TPSS 420	Plant propagation			x					x	x	x	
NREM 429	Spreadsheet modeling for bus/ag			x							x	
ZOOL 101	Principles of zoology	x						x				
NREM 220	Agriculture and resource economics	x					x	x				
TPSS 236	Renewable energy and society	x					x	x			x	
BIOL 401	Molecular biotechnology						x	x	x		x	
BIOL 402	Principles of biochemistry						x	x	x			
BIOL 408	Molecular cell biology II						x	x	x			
BIOL 441	Basic biochemistry						x	x	x			
TPSS 322	Marketing perishable products										x	
TPSS 351	Enterprise management										x	

Does the material cover the Hawaii DOE Science Standards?

Table 2: Curriculum Units That Address the Hawaii Department of Education Science Standards for Biological Science, Chemistry, Physical Science, Environmental Science, Botany and Zoology

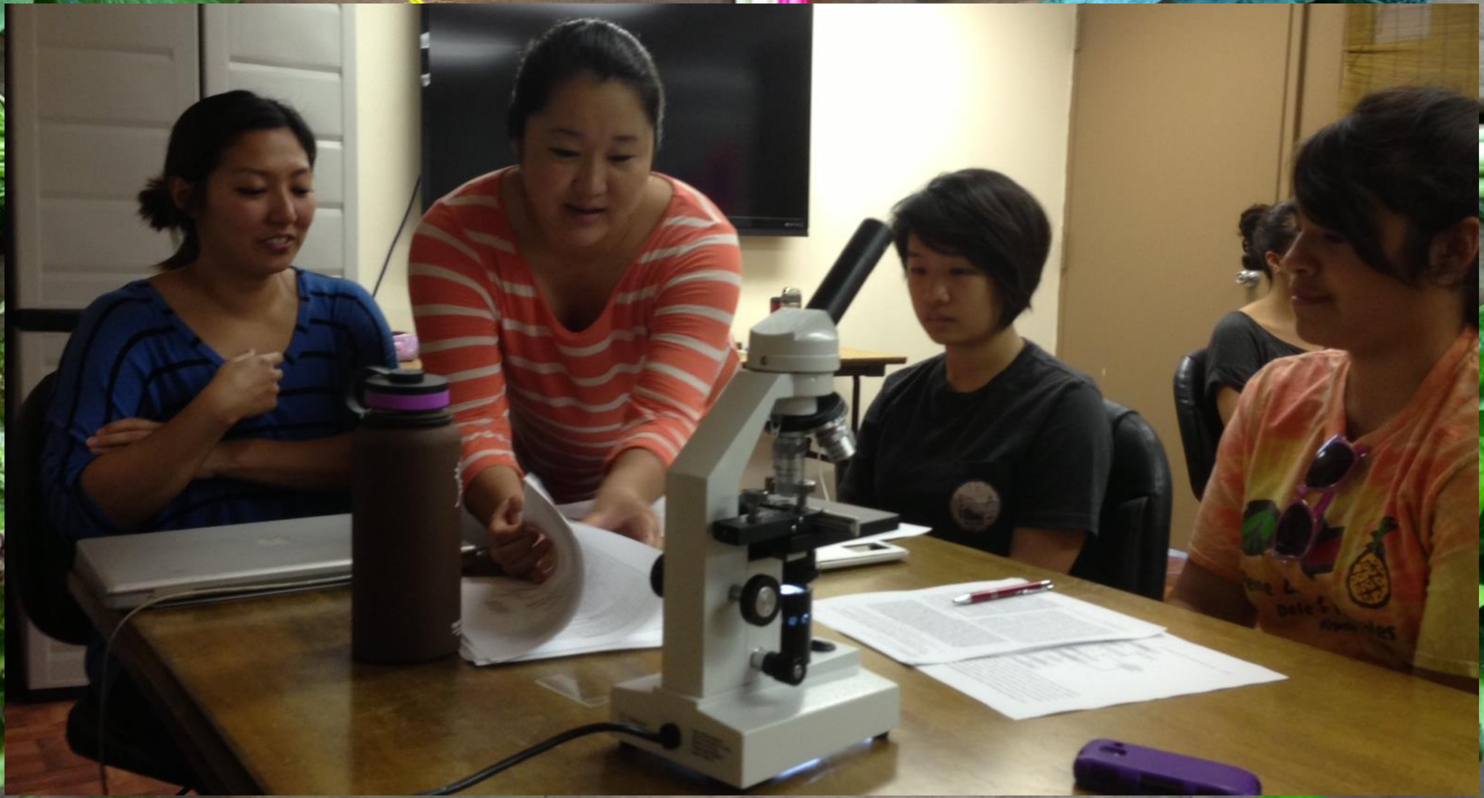
HAWAII DEPARTMENT OF EDUCATION SCIENCE STANDARDS	U1: nutrition	U2: soil	U3: planting	U4: water	U5: compost	U6: hydrop.	U7: aquap.	U8: nutrients	U9: IPM	U10 resrch.
Standard 1: Discover, invent, and investigate using the skills necessary to engage in the scientific process	x	x	x	x	x	x	x	x	x	x
2: Understand that science, technology, and society are interrelated	x	x	x	x	x	x	x	x	x	x
3a: Understand the unity, diversity, and interrelationships of organisms, including their relationship to cycles of matter and energy in the environment	x	x	x		x	x	x		x	x
3b:Understand the metabolism, anatomy, and physiology of plants (cells, tissues and metabolism)			x					x	x	x
3c: Understand the relationship between the structure and function of an animal's body							x		x	
3d: Understand different states of matter		x		x		x	x			
4a: Understand the structures and functions of living organisms and how organisms can be compared scientifically in terms of cells, tissues, organs and organ systems	x		x							
4b: Understand interactions between plants, the environment, and humans	x		x		x			x		x
4c: Understand the interaction of animals with their environment							x		x	
4d: Understand properties of the periodic table, atoms and bond formation				x						x
4e: Understand the interconnections of living systems					x	x	x			x
5a: Understand plant classification, genetics and evolution			x							
5b: Understand genetics and biological evolution and their impact on the unity and diversity of organisms			x							
6: Understand forms of energy and energy transformations and their significance in understanding the structure of the universe	x			x	x					
7: Understand how chemical reaction rates are affected				x						

Do students learn needed trades skills?

They showed significant increases (on pre- to post-observational checklists) in hands-on skills in carpentry, soil preparation, plant propagation, plant care, hydroponics, cooking and group leadership and participation.

Do teens learn problem-solving skills?

Teens regularly applied conceptual learning to solve real-world problems in farming, cooking and business and to design, carry out and present research studies.



Do participants' attitudes and life-styles change?

Life style Outcomes	Pre-Teen Internship		Post-Teen Internship				
	M	sd	M	sd	df	t	p
How confident are you about your parenting abilities?	3.2	0.887	4.23	0.774	29	-4.883	<0.001
How much do you trust your child?	3.37	0.999	4.17	0.699	29	-4.12	<0.001
**How strongly do you believe you should control your child?	3.1	1.062	2.67	0.884	29	2.765	0.01
**How worried are you about your child?	3.07	1.337	2.63	1.189	29	2.149	0.04
How skilled are you in leading your family?	3.23	0.728	3.9	0.803	29	-4.817	<0.001
How much initiatives does your child show?	3.27	0.944	4.13	0.9	29	-5.278	<0.001
How cooperative is your child with others?	3.47	0.86	4	0.83	29	-3.002	0.005
How well do you resolve differences in your family?	3.17	0.874	3.77	0.817	29	-4.039	<0.001
How passionate is your child about some interest or activity in her/his life?	3.77	1.073	4.1	0.96	29	-2.065	0.048
How passionate are you about some interest or activity in your life?	3.6	0.968	4.07	0.74	29	-3.751	0.001
**How much conflict do you have you inr family?	3.53	1.306	2.53	1.042	29	4.664	<0.001
How well does your child do at school?	3.23	0.774	3.63	0.85	29	-2.693	0.012
**How much trouble is your child in?	2.4	1.303	2.03	1.159	29	2.362	0.025
How well does your child get along with others?	3.4	1.102	4.13	0.9	29	-4.626	<0.001
How confident are you that your child will have a good life?	3.5	1.106	4.17	0.913	29	-3.959	<0.001
How healthy is your life style?	3.3	0.952	4.1	0.803	29	-4.558	<0.001

Pre- and post-program parent questionnaires showed statistically significant increases in students' school grades, interest in pursuing science in high school and college, college applications, hands-on skills, self-confidence and initiative.

Likes himself.

Is an expert on fish.

Graduated.

Will enter college in the fall.