Exploring Student Perspectives and Experiences in a Hands-On, Project-Based Aquaponics Unit

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Aquaponics Defined

The integration of:

Recirculating Aquaculture

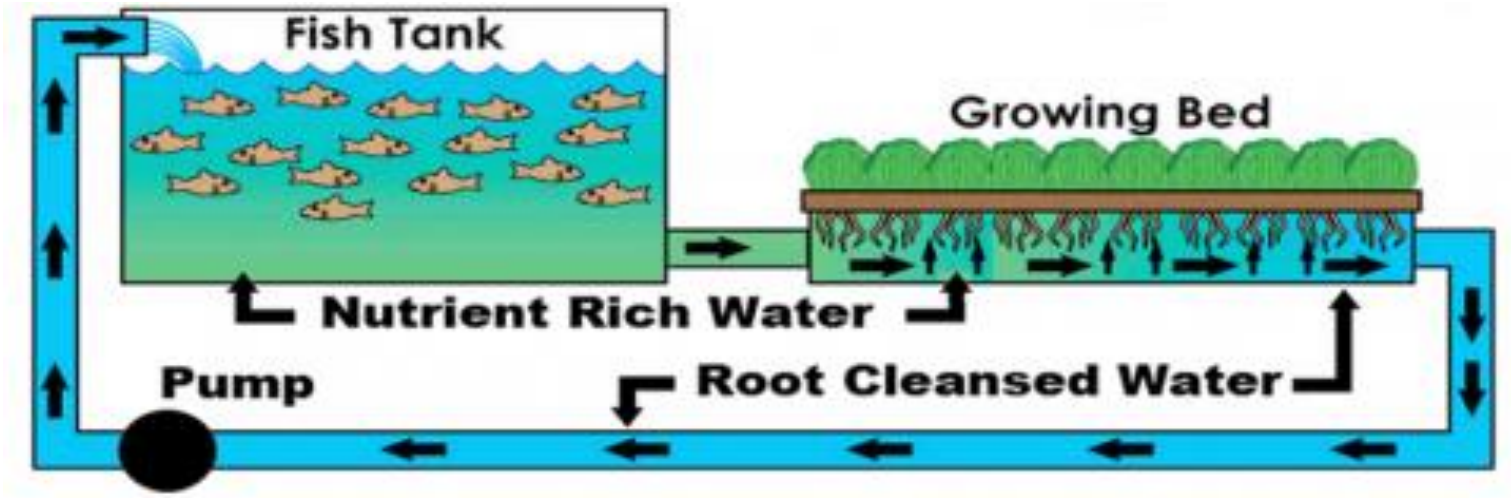
Hydroponics

Not just hydroponics + aquaculture - Creating an *ecosystem

Aquaponics - Hybrid System

- Fish wastewater is utilized as a nutrient source for the plants grown in soilless culture.

- Efficient sustainable method of growing plants and fish together in a closed recirculating loop system.



Aquaponics Experience








- Provide students opportunities to study **ecosystems** and their interactions

Rationale

- Engage learners in authentic **hands-on** PBL environments that mirrors what real-life ***aquaculture scientists*** do.

- Boost curiosity and interest in STEM, aquaculture, and aquaponics.

- Lack of documented research in this context.

Strategy of Project-Based Instruction?

- Engage students to carry out investigations that relate to a **central driving question** . . .

- Make predictions
- Design experiments
- Collect and analyze data
- Observe trends & draw conclusions
- Communicate their ideas and findings to others by group presentation

Setting

- Six (6) high school classrooms in Kentucky: **Eminence Independent**, **Fleming County**, **Russellville, Owen County**, **Jessamine Career and Technology Center**, and **Scott County**.

- 10-20 students and one teacher from each school are participating in the project.

Selection of Sites

- School selection was on the basis of **accessibility** and **rural/small town** and **suburban** characteristics.

Identifying the Phenomenon

- ***Carrying capacity*** is the phenomenon under study described in the NGSS-HS-LS2-1.

Primary Foundational Concept:

Ecosystems: Interactions, Energy, and Dynamics

Utilizing NGSS

***NGSS-HS-LS2-1**

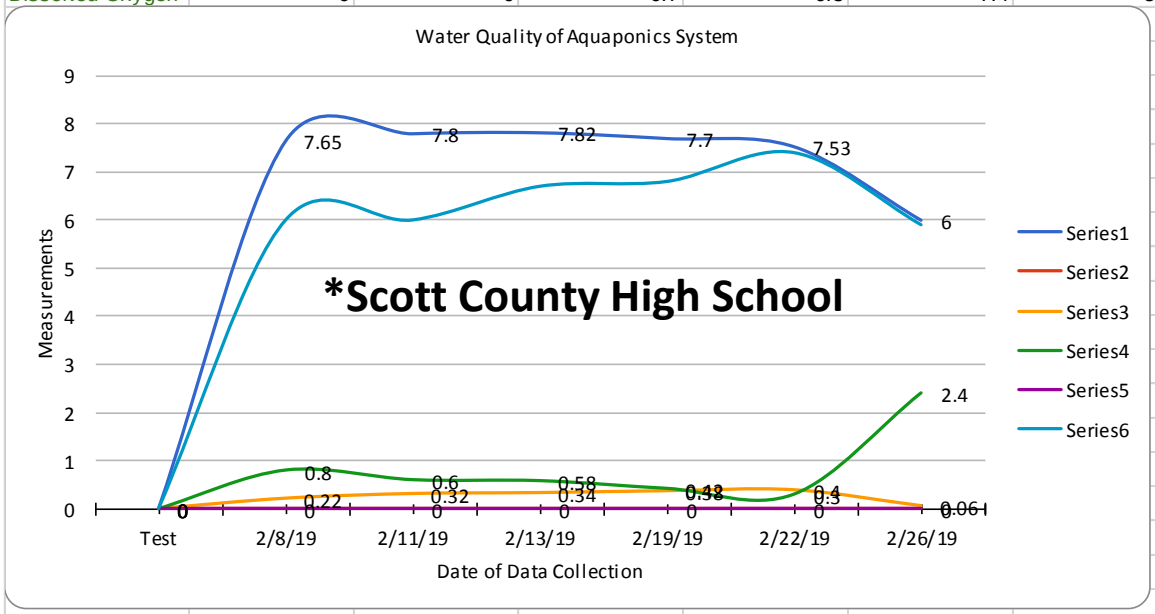
- Uses **mathematical representations** to support explanations of factors that affect *carrying capacity* of ecosystems at different scales.

- Emphasis is on **quantitative analysis** and comparison of the relationships among interdependent factors.

Utilizing NGSS

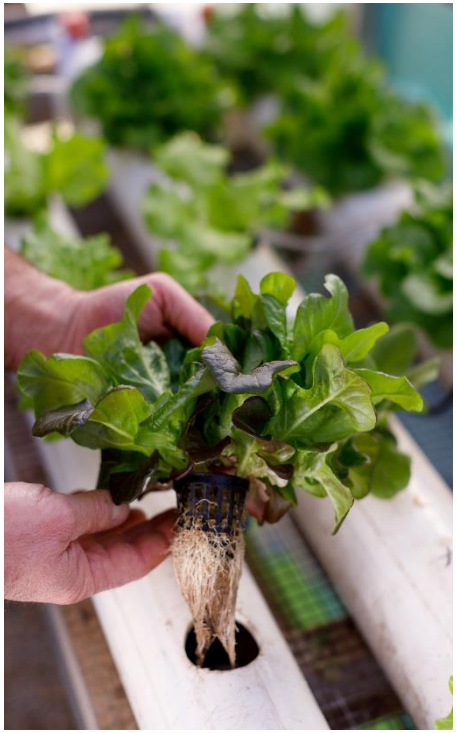
- Finding the **average**, **identifying the trends**, and using **graphical comparisons** of multiple sets of data (NGSS-LS2-2).

Test	2/8/19	2/11/19	2/13/19	2/19/19	2/22/19	2/26/19
pH	7.65	7.8	7.82	7.7	7.53	6
Temperature (F)	73^F	72^F	72^F	73^F	73^F	73^F
Nitrite	0.22	0.32	0.34	0.38	0.4	0.06
Ammonia	0.8	0.6	0.58	0.42	0.3	2.4
Alkalinity	N/A	N/A	N/A	N/A	N/A	N/A
Dissolved Oxygen	6	6	6.7	6.8	7.4	5.9



Driving Research Question

- Central driving research question students are investigating – **How do different levels of nutrient input affect the *carrying capacity* in an aquaponics ecosystem?**



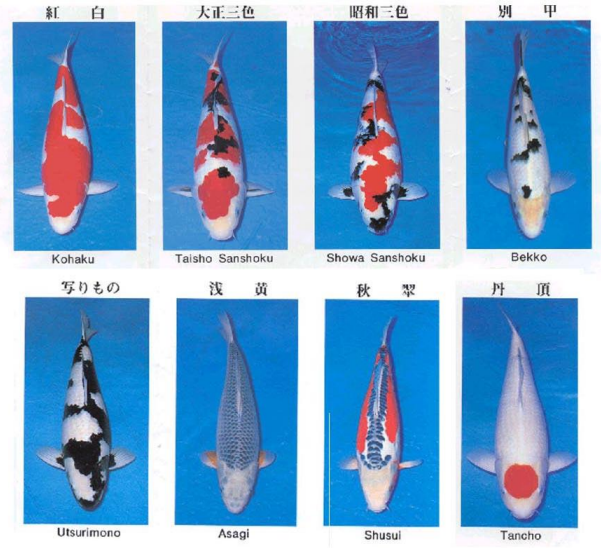
Carrying Capacity Investigation

- Participating schools were randomly assigned to a nutrient level:
- **Minimum** (low; baseline feeding slightly above maintenance)
- **Maximum** (high; feeding for maximum growth)
- Duration of investigation = **8 weeks**

Carrying Capacity Investigation

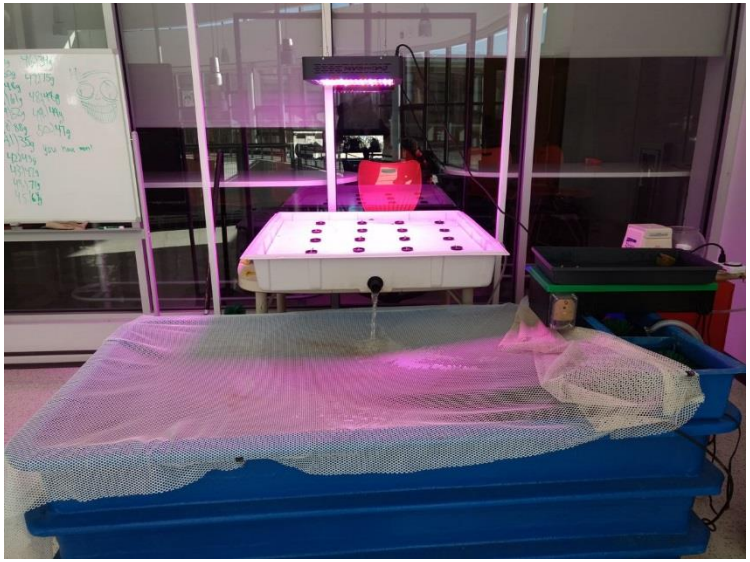
- Juvenile Koi carp are fed daily a percentage of body weight of either **2 or 4%.**

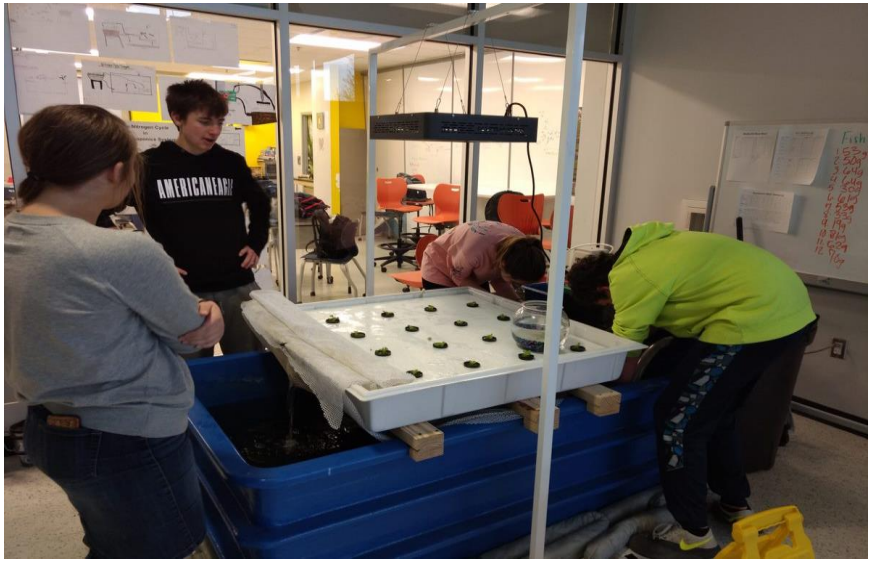
- Students are sampling 10-15 fish weekly and individually weighing them to obtain accurate feed amounts.



Carrying Capacity Investigation

- Focus will be on the **nutrients** introduced into the aquaponics system.





- How that may affect the **productivity** (in response to nutrient input) and **challenge the functioning** of the ecosystem in terms of **resources availability.**

Water Quality

- Collect and analyze water quality data twice weekly:
  - Dissolved oxygen
  - Water temperature
  - pH
  - Total ammonia nitrogen (TAN)
  - Nitrite
  - Nitrate
  - Alkalinity

Carrying Capacity Investigation

Investigate growth performance of fish and plants:

- ❖ Finding the mass - fish and "edible" plant biomass:
- Initial average weight
- Final average weight
- Weight gain (%) of fish
- Specific growth rate (%/day) of fish
- Survival percentage of fish
- Calculating feed efficiency ratios (FCR)
- % Body Weight of fish biomass

Collaborative Tasks with Peers

- Students working in small groups assigned one of eight (8) job descriptions each week:

1. Research Supervisor
2. Photographer/Reporter
3. Ichthyologist- Feeding and Behavior Observation
4. Ichthyologist-Biomass
5. Environmental Scientist – (Ammonia, Nitrite, pH)
6. Environmental Scientist – (Alkalinity, DO, Temp)
7. Systems Engineer
8. Botanist – Lighting and Plant Biomass

Student Group Presentations

***Carrying Capacity Investigation:**

- Several focal students (2-4 total) from each participating school will be selected by their teacher and peers to orally present their results.
- Focal students, teachers, and researcher will meet at a designated location.
- Student focus group interview after presentations.

Connections to Crosscutting Concepts and the Nature of Scientific Inquiry

- As students work through their *carrying capacity* investigation, they will think about the following:

a) The importance of identifying patterns and trends.

b) How their aquaponics RAS can be used as a model to study natural phenomena.

c) How living things or ecosystems go through periods of stability and change.

d) The different types of investigations that can be designed and carried out by scientists as it relates to aquaculture and aquaponics.

Use of Mini-Ecosystems

- Students set up their own group experiments that are relevant and meaningful to them.
- Four (4) mini-ecosystems per school
- Duration of investigation = **4 weeks**

***Relevant research**

Student Oral Group Presentations

*__Mini-ecosystem investigations__:

- Group presentations will be shared and critiqued by those in the classroom similar to the way scientists share their work within research communities.

Benchmark Lessons

***Scaffolding**

1. Introduction to aquaponics
2. Benefits of aquaponics
3. Introduction to bacteria
4. Benefits of bacteria
5. Introduction to aquaculture
6. Introduction to ecosystems
7. Seven video-based lectures

Mrs. Mullen (Russellville HS)

Goal - Develop students' content knowledge

Research Methodology

- **Qualitative research methods:** provides an in-depth understanding of people's experiences in a specific environment and allows stories to be told in context and evidence drawn from several methods of data collection.

Open-Ended Research Question

1) How do students describe their *attitudes* toward *STEM in general* and *aquaculture* and *aquaponics* in particular as a result of their direct experiences in the project?

"Self-reported engagement, interest, attention, curiosity, drive, passion, and enjoyment"

***Attitudes (e.g., feelings, emotions, opinions)**

Open-Ended Research Question

2) How do students describe their *interest* towards a *future STEM-related career* as a result of their direct experiences in the project?

"Educational and career aspirations, decision-making, actions, choices"

***Future career pathways (e.g., actions, career choices)**

Open-Ended Research Question

3) Does hands-on participation *change* students' depth of *understanding* of the science and math concepts in ecological relationships?

Assessment of Results

How will the project be measured?

1. Post student **focus group interviews**

a) 8-10 per classroom

b) 2-3 focal students per school

2. **Individual interviews** (2-4 per classroom)

3. **Student journal reflections** (2-4 per classroom; personal document)

a) Weekly Job Report – All students select one question.

❖ Variety of data collection methods (i.e., triangulation)

Assessment of Results

How will the project be measured?

4. **Teacher journal reflections** (e.g., personal document)

5. Pre and post **carrying capacity assessment**

6. Pre and post **questionnaire**

❖ Variety of data collection methods (i.e., triangulation)

Assessment of Results

Other data collection approaches to consider:

7. **Teacher/student interviews with media** (e.g., public document)

8. **Interview teachers** to obtain their insights of the project

❖ Variety of data collection sources (i.e., triangulation).

Emerging Open-Ended Questions for Teachers

- How do teachers describe new insights learned as a result of their participation in the project-based unit?
- Will the teachers experiences have a positive or negative influence to continue using the project-based methods in the future?
- Will teachers be able to readily choose among the NGSS to decide which ones best apply to add usefulness without becoming redundant?

Data Analysis

- Read, organize, and assign **codes** or labels (e.g., indexing) to reveal basic patterns and trends.

Headings taken from observation field notes:

- Students show team work, but primarily worked independently[1]
- Good attitude, enjoyed hands-on construction, had fun doing it[2]
- Refer to written fact sheet and steps versus independent thinking[1]
- Systematic, meticulous, precise, orderly[1]
- Motivation to indulge in this hands-on activity[2]

Data Analysis

- Group participants' beliefs and attitudes into specific **categories**.
- Like codes grouped together or within a cluster and create *cluster titles* (e.g., management) called **categories**.
- A **summary statement** will be developed for each category and these become the *key themes* (e.g., interpretation).

Group into categories (*cluster titles*):

2 Positive attitude and had fun doing hands-on aquaponics activity

2 Excitement after completion

2 Motivated to indulge in activity

Group 2 Codes (*Theme*): **Hands-on, project-based activity was fun and it motivated participants*

Where we are at in the Unit?

Starting Week 5 of the Carrying Capacity Investigation next week!!

Also . . .

Mini-Ecosystem Group Investigations begins next week!!

QUESTIONS?

Aquaponics – Ecosystems & Interactions

- Understand the needs of living things as they “interact” within an ecosystem.
- See that every living thing performs a function (i.e., depending on each other).
- **Plants** perform a needed function for the **fish** and is centered on a shared resource – *water*.
- **Nitrifying bacteria** that make nitrogen available for the plants (i.e., nitrification process).

Long-term Goals of the Project

- Numerous science and agriculture teachers implement this hands-on PBI curricula unit at their schools.

- Aquaponics unit offered as a dual-credit college course for 9-12th grade secondary students.

Long-Term Goals of Project

- Experiences will *stick* with students for years to come.
- They get involved in science and agriculture throughout high school and beyond.
- Students encourage their families and friends to engage in their food raising fish and plants in their local communities.

Utilizing NGSS

- Define problems and design solutions for engineering their recirculating system (NGSS-HS-ETS-1).
- Monitor the nitrogen cycle (NGSS-HS-LS2-4).
- Several other NGSS are bundled in the unit . . .

Utilizing NGSS

***NGSS-HS-LS2-1**

- Ecosystems have *carrying capacities*, which are limits to the number of organisms and populations they can support.

- Significance of phenomenon is dependent upon the scale, proportion, and quantity at which it occurs.

Research Design – Case Study

- Involves a detailed description of the setting or individuals, followed by analysis of the data contained within a starting and ending point.

- Case studies typically include about four to five cases (e.g., location sites) over a certain period of time.

Trustworthiness

- Plan to have participants read field notes and interview transcripts (e.g., Member Checking) to ensure trustworthiness of the study.

- Study is credible and dependable due to member checking of transcripts, triangulation of notes, recordings of interview, and observations of participants.