Foody 12 Engineering Challenge

“Creating a Sustainable Future”
A Case Study approach
By
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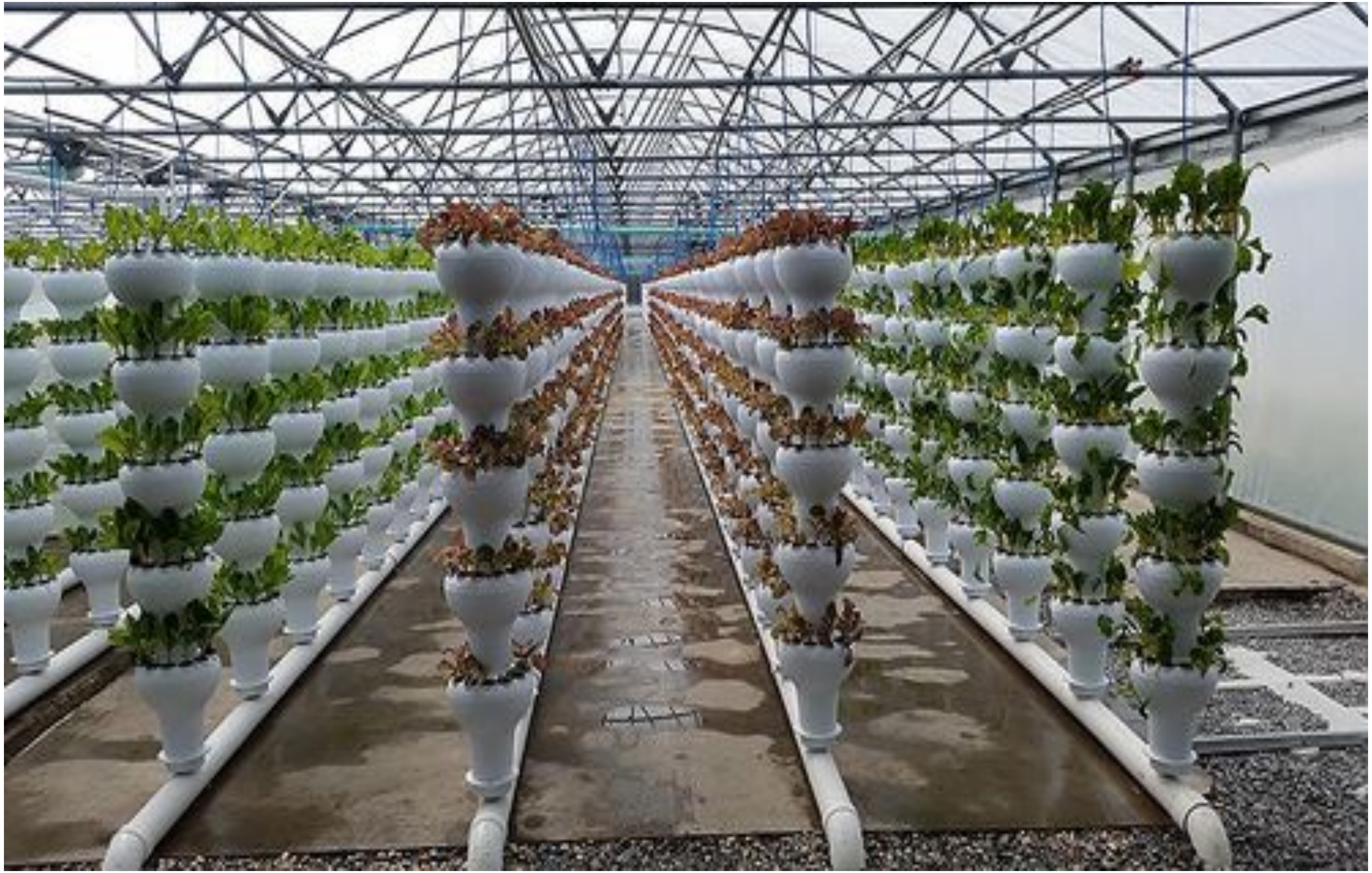
Objectives & Learning Outcomes

1. Students will engage in the engineering process as outlined in the “Science and Engineering Practices” listed in the Next Generation Science Standards.
2. Students will work collaboratively to solve a real world problem.
3. Students will learn about Agronomy and different methods used in food production ranging from soil based to hydroponic to aquaponics systems.
4. Students will develop a plan for sustainable food production that can be scaled down to an individual household.
5. Students will address various HS Life Science performance expectations as outlined in the next slide.

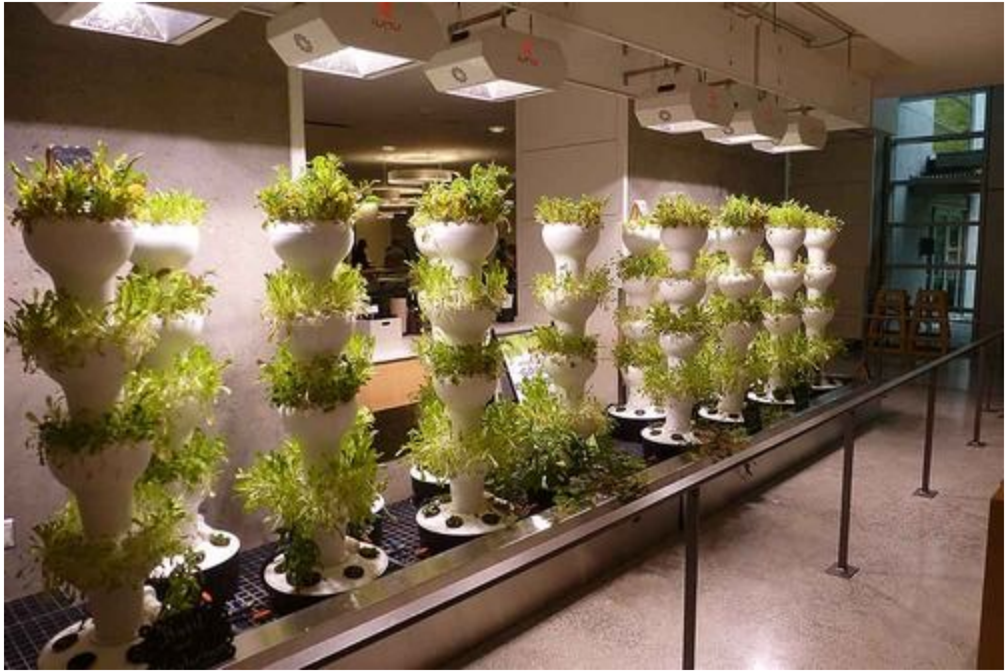
Alignment to Next Generation Science Standards Performance Expectations

HS-LS2-1.
Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]
HS-LS2-5.
Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.] [*Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.*]
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. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]
HS-LS2-7.
Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]



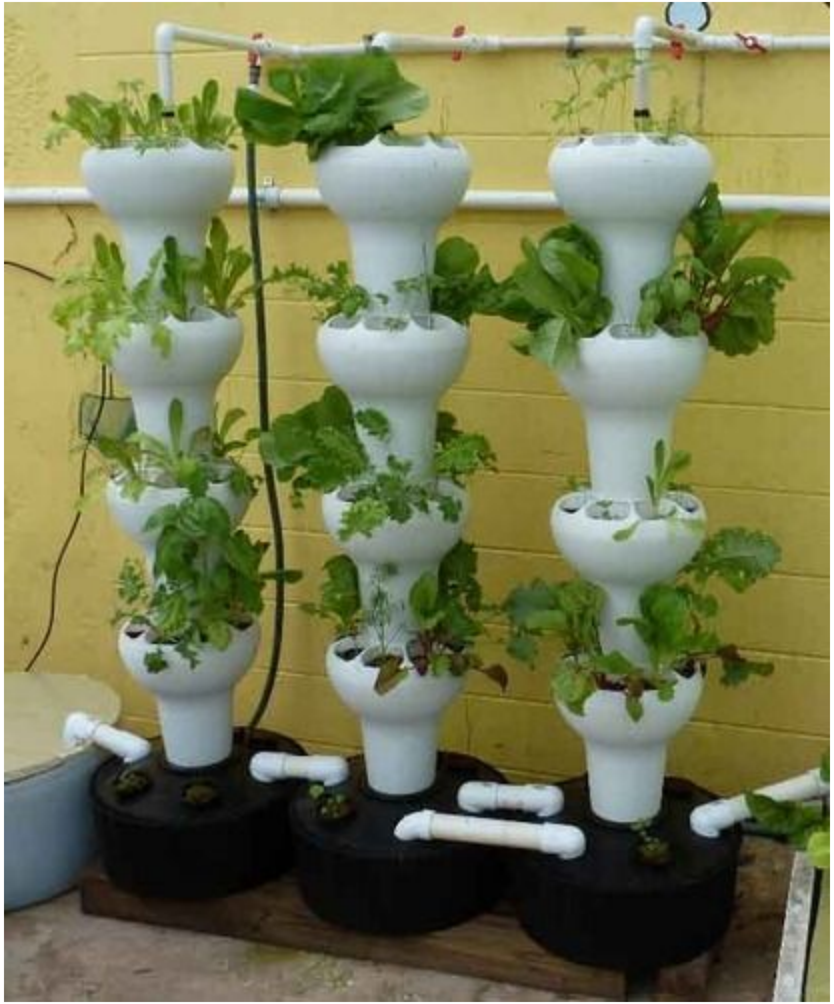
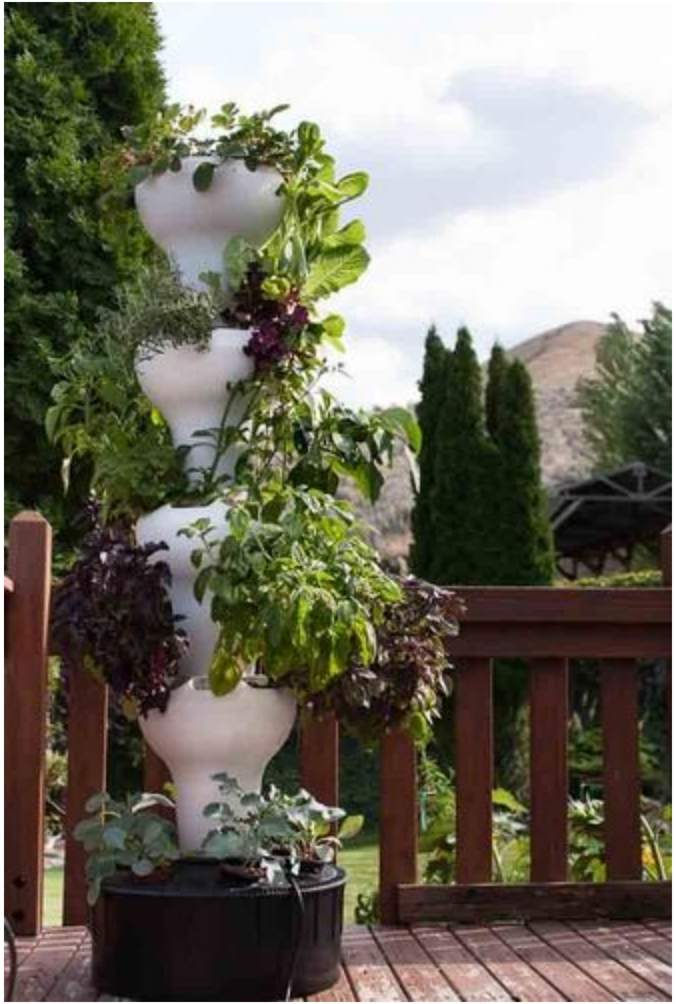
Step 1: What is the Problem?

There is a worldwide pandemic and you are not allowed to travel outside of your home for an indefinite period of time. You can no longer go to the grocery store and the food supply chain has been severely disrupted. You cannot order food online easily and so you are going to have to grow your own food. You currently live in a very urban area with a dense population. You do not have much of a garden space, or space in general, so you have decided to look into vertical gardening. You need to produce high quality nutrient dense food in order to survive. The “Foody 12 Hydroponics Tower” will be your example of a successful hydroponic growing system and your control for this engineering challenge. Your goal is to design a system that works equally good when compared to the Foody 12 or even better. It is time to get to work!



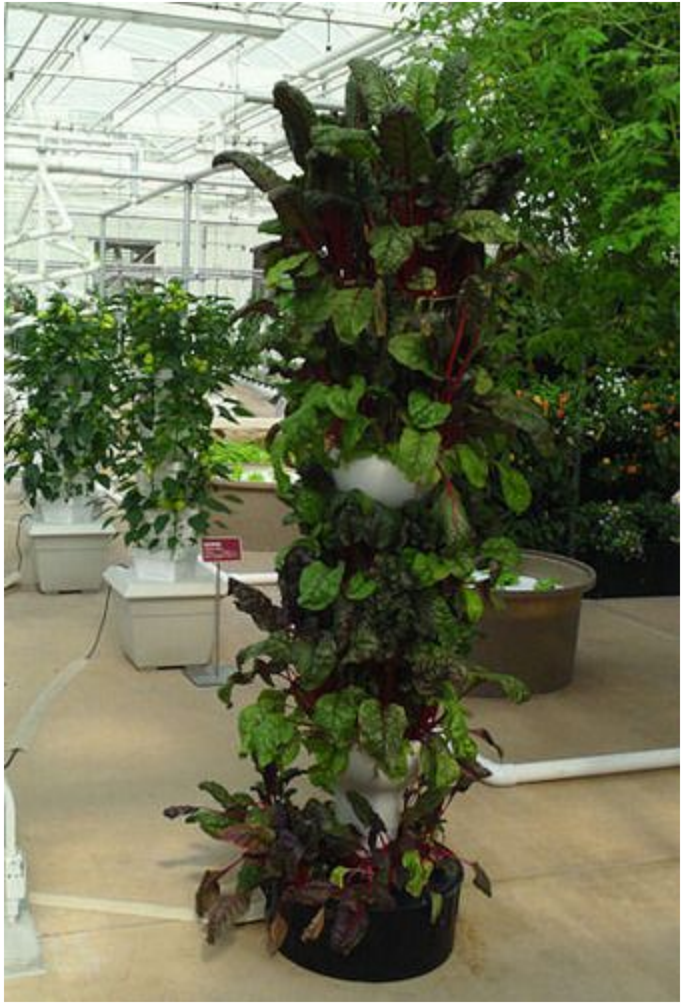
Step 2: Gain Expert Knowledge in the different types of Agronomy

1. Form small groups of 3-5 **agronomy experts.**
2. Group A: Will become experts in ***vertical soil based agricultural systems.***
3. Group B: Will become experts in ***vertical aquaponics systems.***
4. Group C: Will become experts in ***vertical hydroponics systems.***
5. 90 minutes will be alloted for each of the expert groups to research the following topics related to their area of expertise (you may study other areas as needed, but these areas are required working expertise):
    a. Water requirements and water efficiency of the system.
    b. Needed water and/or soil based chemistry measurements such as PH requirements, salt levels (ppm), total dissolved solids, dissolved oxygen, and other required nutrients.
    c. Expected yields and growth rates, make sure you have a systematic way to measure.
    d. Space requirements of the various systems.
    e. Sustainability and use in urban locations or other densely populated areas.

Step 3: Form Co-op Groups with different expertise

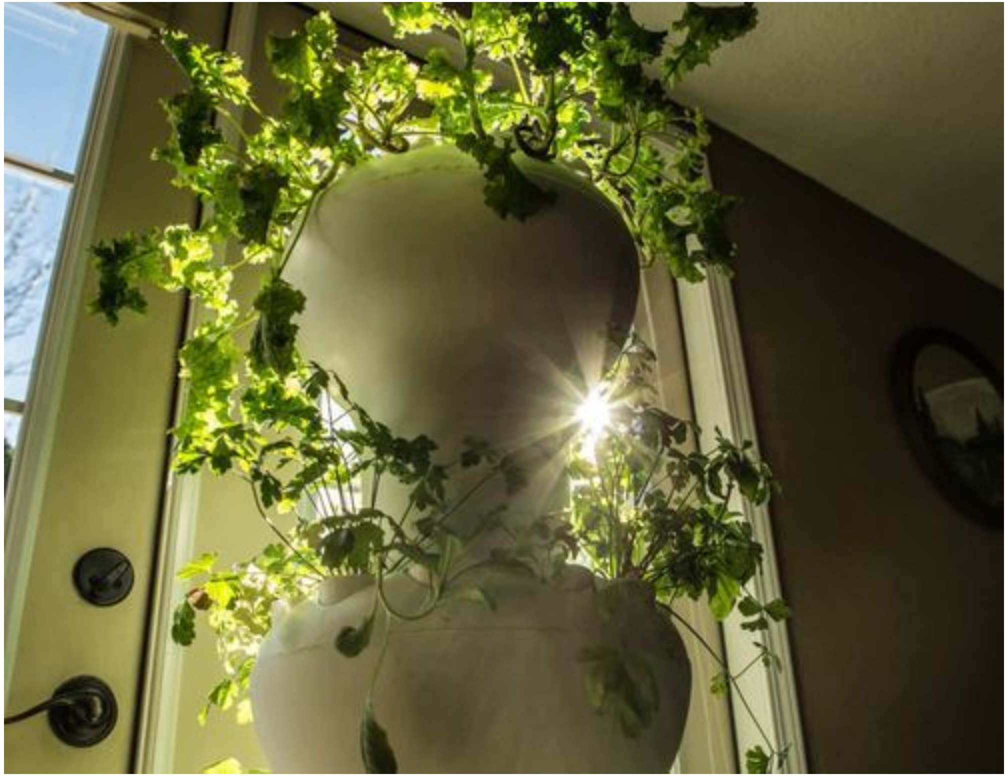
1. After meeting in your expert groups, you will then form groups of 3-5.
2. Make sure you have at least one expert represented from each of the different types of growing systems (one expert in soil based, aquaponics, and hydroponics systems). *It is Ok to have more than one expert if needed, but each group is required to have all 3 systems experts represented within their co-op group.
3. Each member of the group will share what they learned from their expert groups. When you are not the one sharing your expertise, you should take notes on the other two experts as they share their expertise. Eventually you want to become somewhat of an expert in all three areas.



Step 4: Background Questions

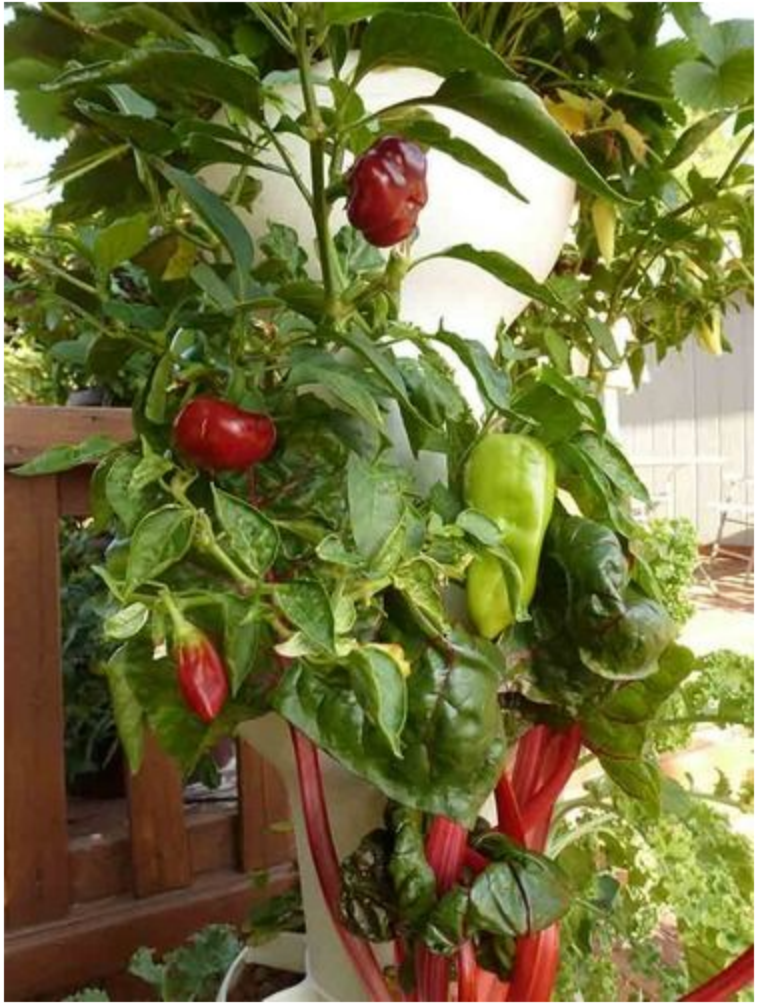
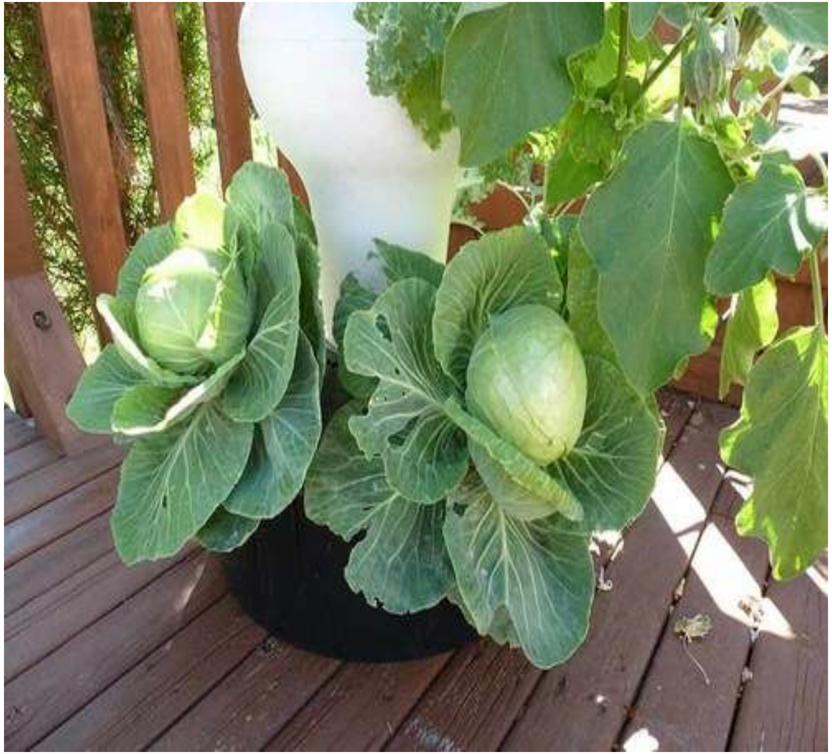
After meeting in your Co-op groups to share your expertise, please answer the following background questions before proceeding with a solution to the stated problem in step 1:

1. What is Agronomy and why is important for us to understand it?
2. Explain the differences between soil based, aquaponics, and hydroponics growing systems.
3. What are the advantages and disadvantages of each type of system?
4. What types of plants could be easily grown in all three types of systems?
5. Which system might be more sustainable in the long term for food production.
6. Which system provides the best option from producing food in an urban setting?
7. What are the advantages of being able to grow your own food?
8. What variables do you need to measure to ensure sustainable growth in each system?
9. How do you calculate total yield of a food crop?
10. List the working components of an example system like the “Foody 12 Hydroponic Tower”



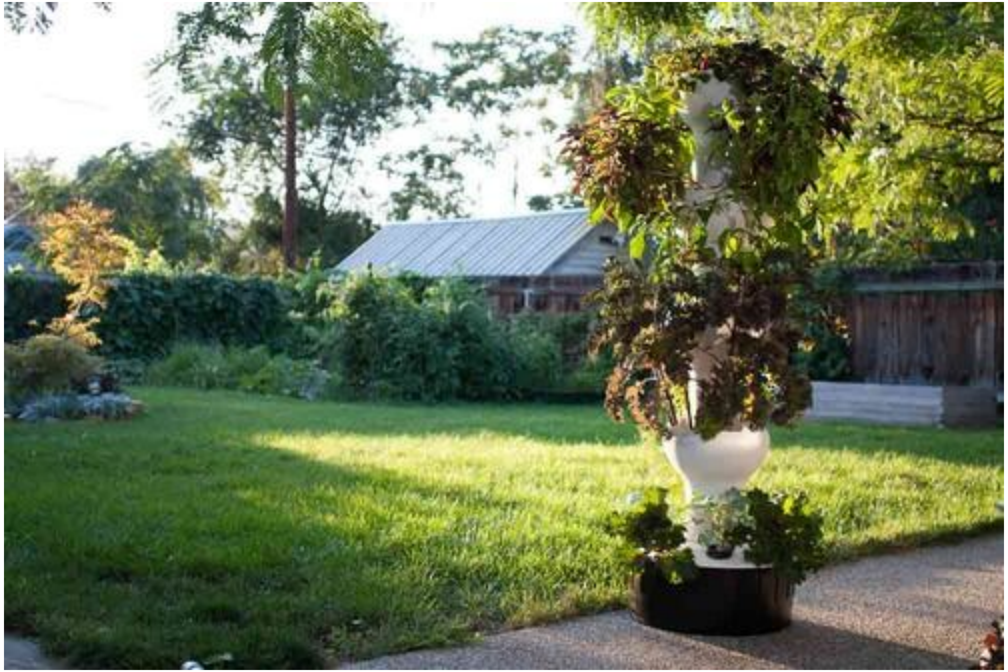
Step 5: Evaluate Constraints & Requirements

1. You design budget is $150 or less. All needed parts/components have to equal $150 or less. You can use existing materials or you can use recycled materials in addition to the materials that you need to purchase.
2. Your system must be able to grow between 40-50 plants.
3. Your system must be able to cycle water and nutrients effectively.
4. Your system needs to be space efficient and take up no more than 5 square feet.
5. Your system must take advantage of vertical space and be no taller than 6 feet.
6. You cost should also include tools needed to measure PH, TDS, salts, and other important nutrients.

Step 6: Brainstorm Solutions

1. Use outside sources to determine all possible solutions given the constraints listed in step 5. Come up with several possible designs and solutions before deciding on a final solution to pursue (don't discount any ideas at this point).
2. Do not rush this step. Take some time to consider all possible solutions. It is Ok if you don't have the answers right away, so please spend some time.
3. Feel free to sketch design ideas, take notes, and doodle.
4. This is the time for you to be creative, don't discount your ideas. You never know which solution is going to be the most viable, or maybe you will use a piece or part of it later.

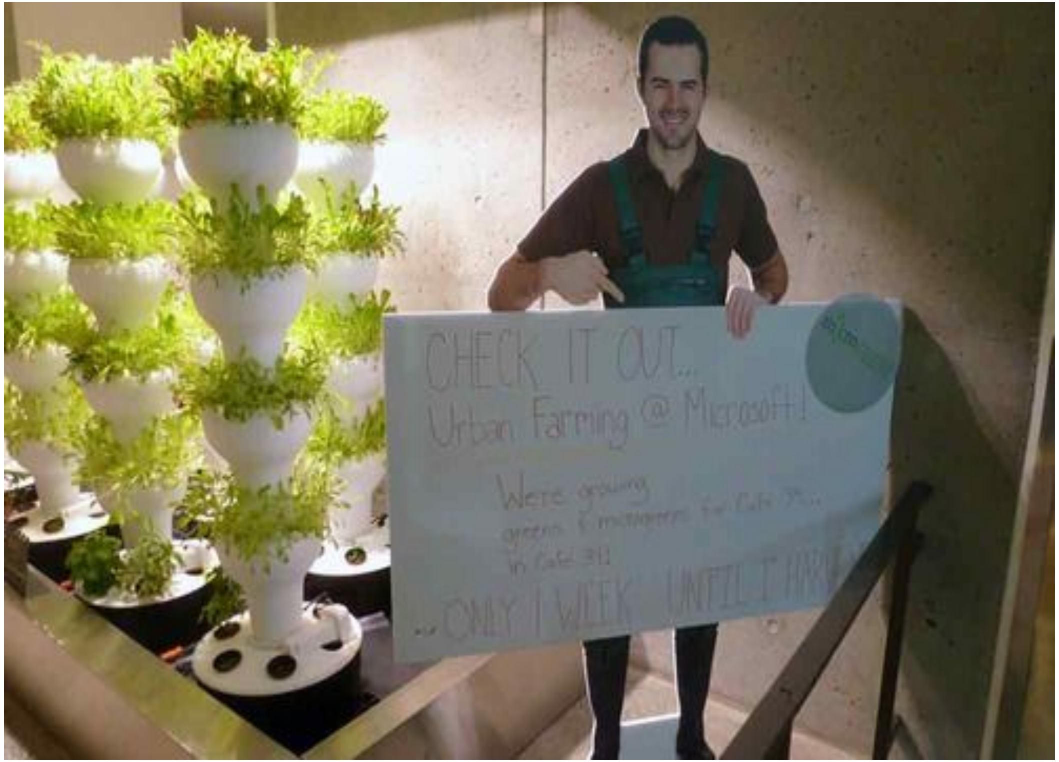


Step 7: Choose the Best Solution & Begin development

1. Now that you have spent some time brainstorming possible solutions, begin to narrow it down to one or two ideas that you would like to pursue, but don't get rid of your other ideas because they might come in handy later.
2. Begin making a list of required materials and make sure that they do not cost above and beyond your $150 budget. Remember recycled or repurposed materials are acceptable to use. You will need to price check and find the best price on the items that you are considering purchasing.
3. Begin sketching or use a digital design option like tinkercad or other software to start creating your first prototype.

Step 8: Build a Prototype

1. Begin collecting the parts to assemble your hydroponics/aquaponics unit.
2. Before planting make sure that the water is properly cycling through the system based on the watering requirements of the plants you have chosen for your system.
3. Begin placing plants in the system.
4. Frequently check water quality.
5. Measure growth rates, yield, and overall health of plants.
6. Take careful notes and decide what future improvements are needed for future prototypes.


CHECK IT OUT...
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Step 9: Test, Re-Test, and Re-design

1. After measuring the productivity of your unit, make the necessary adjustments and re-test.
2. Continue making small adjustments, be careful not make too many changes at once. Give it some time, see what happens based on the changes you made first before making additional changes (don't change too many variables).
3. Consult your other designs from your initial brainstorming session and see if there are any ideas that might work on your current design.
4. Test, re-test, re-design, test, re-test, re-design, etc………
5. Keep a journal of everything you are doing and make careful notes throughout the process.

Step 10: Present your Design

1. For this step you, choose a presentation medium (Google Slides, Prezi, or Storyboard).
2. You will present your design to the rest of the class.
3. Make sure you give some brief background surrounding your design process before proceeding to discuss the elements of your design.
4. Discuss any obstacles you had to overcome and things you might had done differently knowing what you know now.
5. Talk about the elements of the Foody 12 that inspired your design.

Sources:

Next Generation Science Standards: https://www.nextgenscience.org/overview-topics

Foody 12 Vertical Gardens : https://foodyverticalgarden.com/

Engineering Design Process:
https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-process-steps

https://www.teachengineering.org/k12engineering/designprocess