EMPOWERING TEACHERS TOWARDS THE PRAXIS OF STEM

Part III – Urban & Vertical Farming

STEM @ NIE SINGAPORE

NIE NATIONAL INSTITUTE OF EDUCATION SINGAPORE

An Institute of

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Acknowledgements:
This activity is designed jointly by Dominic Koh, Tan Aik Ling, Jaime Koh and Ng Yong Sim
Graphic Design by Danielle Koh

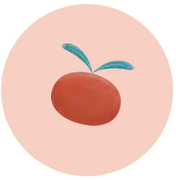
Urban Farming

Activity Booklet

Group Name: _____ Date: _____

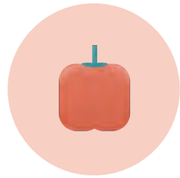
Name: _____
(Group Member 1)

Name: _____
(Group Member 2)



Name: _____
(Group Member 3)

Name: _____
(Group Member 4)



Name: _____
(Group Member 5)

Name: _____
(Group Member 6)

Activity I: Understand the Problem

Mrs. Quek is the principal of LittleRedDot Secondary, a school in Singapore. The school is planning to build and upgrade some of its buildings and facilities. One of the facilities the school is planning to improve is its community garden.

Mrs. Quek shares the same concerns as many Singaporeans about the country's need to increase its local food production to ensure that its residents will have access to a reliable food supply in times of need, like in the current COVID-19 situation. She fully supports Singapore's target to increase its production of food to meet the country's nutritional needs by 2030 from its current rate of 10% to 30%. To help Singapore meet its target, Mrs. Quek would like to have the school's community garden redesigned to support local farming and the school community.

Mrs. Quek would like the students of LittleRedDot Secondary to participate in the redesign of the community garden. She has invited them to share their ideas and submit potential designs for the school committee to consider.

As students of LittleRedDot Secondary, your group has been tasked to redesign the community garden as a space that will be able to produce local food to support the school community. The school is open to keeping the garden where it is or relocating it to another part of the school. You will need to consider three criteria in your design:

1. **Land Area** – The school will allocate 1⁄2 hectare of land area (~ 1 football field) for the community garden. How can you optimize the space provided?
2. **Manpower** – As a community garden, there will be limited people tending to the garden. The school has a gardener on-site and students will tend to the plants on an ad-hoc basis.
3. **Cost-effectiveness** in Monetary and Energy Costs – To determine cost-effectiveness, you should consider the costs to initially build and maintain the community garden.

As a group, you are to present your recommended solution to Mrs. Quek and the school committee.

Activity II: Define the Problem

Mrs. Quek needs a way to A _____ *(verb)*

because B _____

_____ *(surprising insight).*

Activity III: Research the Problem

There are four different types of urban farming that can be used for the community garden.

01

Indoor Farming

02

Outdoor Farming

03

Rooftop Farming

04

Vertical Farming

Compare and contrast the different urban farming types. What are the advantages and disadvantages of each type for the school community garden?

Type	How it works	Advantages	Disadvantages
Indoor Farming			
Outdoor Farming			
Rooftop Farming			
Vertical Farming			

Activity IV: Ideate the Solution

Design a solution that meets Mrs. Quek's needs (Activity II) and considers the criteria (Activity I) and what you have learned about urban farming (Activity III). Again, the school is open to keeping the garden where it is or relocating it to another part of the school.

A Brainstorm

What are the possible ways you can generate to satisfy the criteria? The more ideas the better! Use the space below to sketch or write your ideas.

Brainstorm Area

B Criteria

What does the solution need to have or do to fulfil Mrs. Quek's needs?

1 _____

_____

_____

2 _____

_____

_____

3 _____

_____

_____

_____

4 _____

_____

_____

5 _____

_____

_____

C Narrow Down

Based on the criteria you listed, revisit your possible ways to meet Mrs. Quek's needs. Have they changed, or do you have new ideas? Sketch or write them below!

Activity V: Design the Solution

D Sketch

Select one of your ideas and use the space below to sketch out your idea in detail. Include diagrams or annotations to help others better understand how your solution works.

Sketching Area

How does your solution work? Explain it here.

_____

_____

_____

Activity VI: Test the Solution, Part 1

Share your solution with one of the other groups so they can give you feedback. When sharing your solution, you can:

- Describe your solution and some of its unique features
- Explain how your solution works
- Explain how your solution meets Mrs. Quek's needs
- Explain how your solution takes into consideration the following criteria: land area, manpower, and cost-effectiveness in monetary and energy costs

The group will record their feedback on your solution below:

Group Name: _____

A What do you like about their solution?

We like _____

_____

B What do you wish their solution had or could do?

We wish _____

_____

C How do you think their solution can be changed to better meet Mrs. Quek's needs?

We wonder _____

_____

Activity VII: Revise the Solution

D Sketch

Use the other group's feedback to revise your solution. Sketch your revised solution in the space provided below. Include diagrams or annotations to help others better understand how your solution works.

Sketching Area

How did you change your solution to better meet Mrs. Quek's needs? Explain it here.

_____

_____

_____

Activity VIII: Test the Solution, Part 2

Share your solution with the same group so they can give you feedback on your revised solution. When sharing your solution, you can:

- Describe what changes you made to your solution
- Explain why you made those changes
- Explain how your solution better meets Mrs. Quek's needs

The group will record their feedback on your solution below:

Group Name: _____

A What do you like about their solution?

We like _____

_____

_____

B What do you wish their solution had or could do?

We wish _____

_____

_____

C How do you think their solution can be changed to better meet Mrs. Quek's needs?

We wonder _____

_____

_____

Activity IX: Finalise the Solution

D Sketch

Use the other group's feedback to finalise your solution. Sketch your finalised solution in the space provided below. Include diagrams or annotations to help others better understand how your solution works.

Sketching Area

How did you change your solution to better meet Mrs. Quek's needs? Explain it here.

_____

_____

_____

Activity X: Build the Solution

Now that you've finalised your solution, let's build it! Select from the materials provided to build a 3-D model of your design. Only use the materials you need.

Activity XI: Share the Solution

You will share your solution with the rest of the class. You have 3 – 5 minutes to present your solution, followed by a 3-minute Q&A session. In your presentation, you should:

- Describe your solution and some of its unique features
- Explain how your solution works
- Explain how your solution meets Mrs. Quek's needs
- Explain how your solution takes into consideration the following criteria: land area, manpower, and cost-effectiveness in monetary and energy costs

Use the space below to make notes for your presentation.

Presentation Notes

Activity XII: Reflect on the Solutions

Review the solutions for each group below, including your own.

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be changed to better meet Mrs. Quek's needs?

We wonder _____

_____

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be changed to better meet Mrs. Quek's needs?

We wonder _____

_____

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be changed to better meet Mrs. Quek's needs?

We wonder _____

_____

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be changed to better meet Mrs. Quek's needs?

We wonder _____

_____

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be changed to better meet Mrs. Quek's needs?

We wonder _____

_____

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be changed to better meet Mrs. Quek's needs?

We wonder _____

_____

– End of Activity Sheet –

Urban Farming

Teachers' Notes

Stream	Topic	Estimated Duration
Express	Photosynthesis (Problem-centric)	6 hours

Aim(s)

At the end of the lesson, students should be able to:

Syllabus Learning Outcomes	• Explain the context of limited land space in Singapore. • Explain the problem of food sustainability in Singapore. • Research on different urban farming methods, discuss and decide on the design of the urban farming system for the school community garden. • Sketch the design of the urban farming system. • Build a model of their urban farming system to show how it works. • Present an urban farming system that solves the problem and meets the user's needs.
Engaging students in the Practices of Science	• WOTD: Design an urban farming system that solves a problem and meets a user's needs. Collect feedback to improve the design and consider the limitations of the design. • STSE: Scientific knowledge can be used to develop technologies.
Inculcating VEA	• Creativity: Innovate in developing an urban farming system for the community garden to produce local food to support the school community.

Preparation Notes

Materials/Apparatus (1 set per group)

- Acrylic frame structure simulating stainless steel structure (1)
- Scaled-down planters (10)
- Glue gun (1)
- Glue sticks (5)
- Handheld drill (with twist drill bits of different diameters (2)
- Split pin (10)
- Masking tape, about 2 cm-thick (1 roll)
- Scissors (1)
- Metal wire (~1m)
- Ice cream sticks (20)
- Satay sticks (20)
- Aluminium foil, 30 cm by 30 cm (2 sheets)
- Bubble tea straws (10)
- Standard narrow straw, hard (20)
- Pen knife (1)
- Mounting board, A4 size (4)
- String (1 roll)
- Plastic mesh, 30cm x 70cm (1)
- 1.5L soft drink plastic bottle (2)
- Bean curd plastic bowl (2)
- Extra paper if needed for sketching, A3 size (2)
- Cutting matt (1)
- Wooden board (1) or newspaper for hot gluing
- Rulers for measurement

Materials/Apparatus (for a class)

- Stickers for groups to label their 3-D models
- Any recyclable materials the school thinks would be appropriate for the activity

Safety

Remind students to be careful when using sharp objects.

Suggested Lesson Guide

Prior knowledge: Students should be able to state the factors (light, water and carbon dioxide) needed for plants to conduct photosynthesis. They should also be able to describe the intake of carbon dioxide and water by plants.

Lesson Activity	Pedagogical Considerations
SESSION 1 *This activity is conducted individually.* **STEM Pre-Activity (15 mins)** 1. Issue STEM Pre-Activity Form to assess students' understanding on the concept of STEM and its applications to real-world problems. • If online, provide the link to the students • If paper-based, use the worksheet Minimise teacher facilitation. There should be no teacher facilitation if possible. **Design Pre-Activity (15 mins)** 1. Issue Design Activity Form to assess how students would respond to problems based on their prior knowledge and understanding of STEM. Minimise teacher facilitation. There should be no teacher facilitation if possible.	

Lesson Activity	Pedagogical Considerations
Introduce the Context (20 mins) 1. Show students the National Geographics' Food by the Numbers video (http://bit.ly/foodnumbers). 2. Using the PowerPoint slides and whole class question and answer, teach students that in Singapore, there is small land area and high competition for land use. You can link the video to the topic of food supply in Singapore. As much as possible, the context should be introduced to students via a class discussion. 3. By asking students to identify some uses of land in Singapore (eg. residential, industrial, urban use, etc.), this will help them realise the situation of high land competition and hence, a lack of land left for open-field farming. 4. Next, ask students how Singapore gets her supply of food. Students are expected to answer by saying that Singapore imports most of her food. If students struggle, you can ask additional questions such as, "Where do you think the Hokkaido milk (or any obvious food from abroad) sold in supermarkets come from?" 5. After identifying the fact that most food in Singapore is imported, ask students if they think that it is sustainable/advisable to import all food from other countries. The teacher can prompt students' response by giving the current COVID-19 situation where many severely affected countries are being	**Activating Prior Knowledge:** Students will have learned the factors needed for plants to conduct photosynthesis and the intake of carbon dioxide and water by plants during this process. It is useful to tap on this prior knowledge to check on their understanding and set the context for this lesson. **Setting the Context:** Context is important for students to understand the problem. It also helps students to appreciate the task by making it meaningful and relatable. Class discussion is more student-centered compared to a lecture. Hence it is advised for the introduction of the context to be in the form of a discussion. This allows the teacher to assess the students' level of understanding,

Lesson Activity	Pedagogical Considerations
locked down. Eg. What if Malaysia decides to stop its export of food and necessities to Singapore? This leads to the introduction of the problem of food self-sustainability in land-scarce Singapore. **Activity I: Understand the Problem (20 mins)** 1. Get students to read the scenario in Activity 1. 2. Explain the scenario and task to students. 3. Scenario: To redesign the community garden as a space that will use an urban farming system to produce local food to support the school community. The school is open to keeping the garden where it is or relocating it to another part of the school. **Students' Task:** a. Develop an urban farming system for the community garden to produce local food to support the school community. b. Build a model of their solution using the materials provided. c. Share their solution with the rest of the class.	subsequently helping to fill the gaps in their understanding.level of understanding, subsequently helping to fill the gaps in their understanding. **Setting the Context:** Context is important for students to understand the problem. It also helps students to appreciate the task by making it meaningful and relatable.

Lesson Activity	Pedagogical Considerations
Students will be given a set of constraints to consider in their solution: a. Optimise Land Area b. Optimise Manpower (less labour-intensive) c. Cost-effectiveness (Monetary and Energy Costs) d. Incorporation of recyclable materials Students need to keep in mind that no additional materials are allowed. If students' design involves technological elements, they do not need to build a fully functional technology. They only need to show on the model, how the technology will be built into their solution. *Activities II & III are conducted in groups.* **Activity II: Define the Problem (15 mins)** 1. Students define the problem by identifying the user's needs. **Activity III: Research the Problem (30 mins)** 1. Distribute the list of resources to each group and allocate time for students to review the resources. These resources are stimulus material on urban farming.	**Supporting Self-Directed Learning:** Group discussion allows ideas to bounce off from one another as well as encourages students to ask more questions. **Supporting Self-Directed Learning:**

Lesson Activity	Pedagogical Considerations
2. Assign roles within the group for a more systematic discussion to take place. You may consider the following suggested roles (there could be variation depending on number of students per group): • Three students to review the provided resources. • One student to search for more information online. • Assign group member to act as note-taker to consolidate information obtained from the provided resources and additional information. Students will discuss their findings after reviewing the resources and additional information. Space is provided in the activity booklet for the note-taker to record the group's notes about urban farming and the advantages and disadvantages of using each method for the school community garden. Activity IV is conducted in groups. The teacher should walk around the classroom to facilitate the discussion. The teacher can ask guiding questions to help students better satisfy the criteria and consider what nutrients and factors are required for optimal plant growth. **Conclusion (5 mins)** 1. Conclude the lesson by telling students the agenda for the next lesson: groups will continue to design and build a solution to solve the problem they identified. **Collect Activity Booklets** 1. Collect all activity booklets at the end of the Session 1. They will be used during Session 2	Allowing students to research the topic will help them when they develop their solution. By learning about different urban farming methods, students can better understand what strategies are being adopted.

Lesson Activity	Pedagogical Considerations
SESSION 2 **Briefing (5 mins)** 1. Brief students on the day's agenda: • All groups will design their solution though a process of ideating, seeking feedback on, and revising their solution. • Students will build a 3-D model of their solution using basic materials. *Activities V - X are conducted in groups. The teacher should walk around the classroom to facilitate the discussion. The teacher can ask guiding questions to help students better satisfy the criteria and consider what nutrients and factors are required for optimal plant growth.* **Activity IV: Ideate the Solution (30 mins)** 1. Students begin the process of designing their solution by brainstorming possible ways to meet the user's needs. Space is provided in the activity booklet for students to sketch or write their ideas. 2. Students identify the criteria their solution needs to satisfy to meet the user's needs.	**Empowering learners:** Students are given the autonomy to decide on the design of their urban farming system. **Supporting Self-Directed Learning:** Allowing students to identify the criteria they

Lesson Activity	Pedagogical Considerations
3. Students narrow down the possible ways to meet the user's needs based on the criteria they identified. **Activity V: Design the Solution (20 mins)** 1. Students select the idea they want to pursue as their solution. They need to bear in mind the user's needs and criteria their solution should satisfy as they decide on the structure and features of their solution and sketch their idea. The drawing should be detailed and labelled so that they can refer to the drawing when showing their sketch to others. They should also explain how their solution works. Space is provided in the activity booklet for students to sketch their idea. If they need more space, they can ask the teacher for A3 paper to draw their idea. **Activity VI: Test the Solution, Part 1 (15 mins)** 1. Students seek feedback from another group by sharing their solution. They should show their sketch. They can also consider sharing the following: • Describing their solution and some of its unique features. • Explaining how their solution works.	will have to satisfy and narrow down their ideas to satisfy these criteria will help them in the design of their urban farming system. **Empowering learners:** Students are given the autonomy to negotiate the design of their urban farming system. **Facilitating Collaborative Learning and Providing Feedback:** Allowing students to gather input from their peers supports the active construction of ideas. It allows students to learn from each other to make improvements to their urban farming system.

Lesson Activity	Pedagogical Considerations
• Explaining how their solution addresses the user's needs. • Explaining how their solution takes the criteria into consideration in its design. Space is provided in the activity booklet for the other group to write down their feedback. **Activity VII: Revise the Solution (15 mins)** 1. Students should use the feedback they received to decide how to revise their solution and sketch their idea. The drawing should be detailed and labelled so that they can refer to the drawing when showing their sketch to others. They should also explain how they revised their solution to better meet the user's needs. Space is provided in the activity booklet for students to sketch their idea. If they need more space, they can ask the teacher for A3 paper to draw their idea. **Activity VIII: Test the Solution, Part 2 (15 mins)** 1. Students seek feedback from the same group by sharing their revised solution. They should show their sketch. They can also consider sharing the following: • Describing what changes they made to their solution.	**Supporting Self-Directed Learning:** Allowing students to think about their peers' feedback provides opportunities to develop reflective thinking in how they can make improvements to their urban farming system. **Facilitating Collaborative Learning and Providing Feedback:** Allowing students to gather input from their peers supports the active construction of ideas. It allows students to learn

Lesson Activity	Pedagogical Considerations
• Explaining why they made those changes. • Explaining how their solution better meets the user's needs. Space is provided in the activity booklet for the other group to write down their feedback. **Activity IX: Finalise the Solution (15 mins)** 1. Students should use the feedback they received to decide on their finalised solution and sketch their idea. The drawing should be detailed and labelled so that they can refer to the drawing when showing their sketch to others. They should also explain how they improved their solution to better meet the user's needs. Space is provided in the activity booklet for students to sketch their idea. If they need more space, they can ask the teacher for A3 paper to draw their idea. **Activity X: Build the Solution (30 mins)** 1. Inform students that they will be provided a set of materials which they can choose from to build their solution. They only need to build the structure of their solution. If the solution involves technological elements that are not able to be shown using the given materials, students can show how the technology will be incorporated and explain verbally during their presentation. If the farming	from each other to make improvements to their urban farming system. **Supporting Self-Directed Learning:** Allowing students to think about their peers' feedback provides opportunities to develop reflective thinking in how they can make improvements to their urban farming system. **Empowering learners:** Students are given the autonomy to decide on the choice of materials to be used for the 3D-model of their urban farming system. Having a model helps each group to judge the feasibility of the physical

Lesson Activity	Pedagogical Considerations
system involves multiple replicates of the same structure, students will only have to build one of the replicates. 2. Issue materials to each group so that students can build their solution. 3. Walk around the classroom to facilitate the discussion. • In addition to asking guiding questions to help students better satisfy the criteria and consider what nutrients and factors are required for optimal plant growth, you can also guide students on how to make use of the provided materials. **Conclusion (5 mins)** 1. Conclude the lesson by telling students the agenda for the next lesson: groups will need to finish building their model and prepare for their sharing session. **Collect Activity Booklets and 3-D Models** • Collect all activity booklets and 3-D models the end of Session 2. They will be used during Session 3.	structure of their design. They would have time to test out the general structure and modify their design.

Lesson Activity	Pedagogical Considerations
SESSION 3 **Briefing (5 mins)** 1. Brief students on the day's agenda: • All groups will continue to build their solution. • All groups will share their solution with the rest of the class. *Activities X - XII are conducted in groups.* **Activity X (cont'd): Build the Solution (30 mins)** 1. Students are to continue building their model. Students should label their 3-D models so that they can refer to it during the sharing session. 2. Walk around the classroom to facilitate the discussion. • In addition to asking the guiding questions to help students better satisfy the criteria and consider what nutrients and factors are required for optimal plant growth, you can also guide students on how to make use of their provided materials. **Activity XI: Share the Solution (20 mins)** 1. Students prepare their presentation to share their solution with the rest of the class.	**Empowering learners:** Students are given the autonomy to decide on the choice of materials to be used for the 3D-model of their urban farming system. Having a model helps each group to judge the feasibility of the physical structure of their design. They would have time to test out the general structure and modify their design. **Supporting Self-Directed Learning:** Group discussion allows ideas to bounce off from one another as well as encourages students to ask more questions.

Lesson Activity	Pedagogical Considerations
Students should include the following points in their presentation: • Describe their solution and some of its unique features. • Explain how their solution works. • Explain how their solution meets the user's needs. • Explain how their solution takes the criteria into consideration in its design. Space is provided in the activity booklet for students to make notes for the presentation. **Activity XII: Reflect on the Solutions (1 hr)** 1. Inform students that all groups should participate when they present their model. They should show their 3-D model in their presentation. 2. Inform students that they should listen as each group presents its solution. They are to write down their reflection of each solution, including their own. While each group is presenting, the audience should be focused and attentive. The audience also needs to reflect on the presenting group's solution. You are to guide the students in reflecting on the solutions. Questions raised should be specific to the particular solution and presentation. You can use the following guiding questions to help students narrow down their questions:	**Facilitating Collaborative Learning and Providing Feedback:** Allowing students to gather input from their peers supports the active construction of ideas. It allows students to learn from each other to make improvements to their urban farming system. **Supporting Self-Directed Learning:** Allowing students to think about their peers' feedback provides opportunities to develop reflective thinking in how they can make improvements to their urban farming system.

Lesson Activity	Pedagogical Considerations
• From the group's presentation, do you think they have addressed Mrs. Quek's needs? If yes/no, how so? • Which criteria do you think the group satisfied in their solution? How did they do it? • Do you think that their solution will be able to produce enough food to support the school community? Why/why not? • How do you think the solution will work if it is implemented in the school? Do you foresee any potential problems that may arise from this solution? The reflection will take place after each presentation. Space is given in the activity booklet for students to write down their reflections. **Conclusion (5mins)** 1. Students label their 3-D models with their class and group name. 2. Conclude the lesson by summarising the activities that students have undergone for the past three sessions.	**Supporting Self-Directed Learning:** Group discussion allows ideas to bounce off from one another as well as encourages students to ask more questions.

References

Food by the Numbers

• http://bit.ly/foodnumbers

(links to https://www.youtube.com/watch?v=CB9Enh6yPow)

Urban Farming

• http://bit.ly/UrbanFarmingGrowth

(links to https://www.ura.gov.sg/Corporate/Resources/Ideas-and-Trends/feeding- the-city-growth-of-urban-agriculture)

Indoor Farming

• http://bit.ly/JPIndoorFarming

(links to https://www.youtube.com/watch?v=qJMZRIRkZWs)

Outdoor Farming

• http://bit.ly/AUSOutdoorFarming

(links to https://www.youtube.com/watch?v=y6qKV_NPuZY)

Rooftop Farming

• http://bit.ly/CARooftopFarming

(links to https://www.youtube.com/watch?v=0SzTSepQuMU)

• https://www.citiponics.com/

Vertical Farming

• http://bit.ly/USVerticalFarming

(links to https://www.youtube.com/watch?v=3Ww2TP_tU7o)

• http://www.skygreens.com/

Creators of this lesson (if any)

Names of teachers involved in the creation	Pedagogical Considerations

– End of Teachers' Notes –

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Urban Farming

Annex A: Suggested Answers

As students of LittleRedDot Secondary, your group has been tasked to redesign the community garden as a space that will be able to produce local food to support the school community. The school is open to keeping the garden where it is or relocating it to another part of the school. You will need to consider three criteria in your design:

1. **Land Area** – The school will allocate 1⁄2 hectare of land area (~ 1 football field) for the community garden. How can you optimize the space provided?
2. **Manpower** – As a community garden, there will be limited people tending to the garden. The school has a gardener on-site and students will tend to the plants on an ad-hoc basis.
3. **Cost-effectiveness** in Monetary and Energy Costs – To determine cost-effectiveness, you should consider the costs to initially build and maintain the community garden.

As a group, you are to present your recommended solution to Mrs. Quek and the school committee.

Activity II: Define the Problem

Mrs. Quek needs a way to (A) Accept any reasonable response _____ *(verb)*

because (B) Accept any reasonable response _____

_____ *(surprising insight).*

Activity III: Research the Problem

There are four different types of urban farming that can be used for the community garden.

01

Indoor Farming

02

Outdoor Farming

03

Rooftop Farming

04

Vertical Farming

Compare and contrast the different urban farming types. What are the advantages and disadvantages of each type for the school community garden?

Type	How it works	Advantages	Disadvantages
Indoor Farming	• Growing crops inside buildings. • Accept any other reasonable response.	• Protected from the elements such as strong sunlight, heavy rain and strong winds. • Accept any other reasonable response.	• Small scale. • Only specific plants requiring less sunlight can be grown. • Accept any other reasonable response.
Outdoor Farming	• Growing crops/plants in a plot of land. This plot of land is usually large. • Accept any other reasonable response.	• Different crops can be grown. • Large scale farming. • Accept any other reasonable response.	• A lot of land is needed. • Require resources such as manpower for harvesting. • Accept any other reasonable response.
Rooftop Farming	• Growing crops/plant on the top of house. Maximise the use of limited space. • Accept any other reasonable response.	• Exposure to sun and rain. Natural environment hence minimum care. • Accept any other reasonable response.	• Birds and other animals may eat the plants. • Possible accumulation of stagnant water resulting in mosquito breeding ground. • Cost involved in building the infrastructure for plants. • Accept any other reasonable response.
Vertical Farming	• Planning crops/plants in vertical structures with aeration and sometime artificial light. • Accept any other reasonable response.	• Less land is required. • Different crops can be grown in the same vertical structure. • Accept any other reasonable response.	• Need to build upwards hence likelihood of toppling accidents is higher. • The amount of light that the plants are exposed to is uneven. • Accept any other reasonable response.

Activity IV: Ideate the Solution

Design a solution that meets Mrs. Quek's needs (Activity II) and considers the criteria (Activity I) and what you have learned about urban farming (Activity III). Again, the school is open to keeping the garden where it is or relocating it to another part of the school.

A Brainstorm

What are the possible ways you can generate to satisfy the criteria? The more ideas the better! Use the space below to sketch or write your ideas.

Students' ideas may vary.

Notes:

Brainstorm Area

B Criteria

What does the solution need to have or do to fulfil Mrs. Quek's needs?

1. Accept any reasonable response (for example, avoid collection of stagnant water, ensure light is unblocked, ease of watering plants, etc.).
2. Accept any reasonable response.
3. Accept any reasonable response.
4. Accept any reasonable response.
5. Accept any reasonable response.

C Narrow Down

Based on the criteria you listed, revisit your possible ways to meet Mrs. Quek's needs. Have they changed, or do you have new ideas? Sketch or write them below!

Students' ideas may vary and are dependent on their criteria.

Narrowing Down Area

Activity V: Design the Solution

D Sketch

Select one of your ideas and use the space below to sketch out your idea in detail. Include diagrams or annotations to help others better understand how your solution works.

Students' ideas may vary.
Check that the drawing is detailed and labelled.

Sketching Area

How does your solution work? Explain it here.

Responses may vary and are dependent on students' design.

Activity VI: Test the Solution, Part 1

Share your solution with one of the other groups so they can give you feedback. When sharing your solution, you can:

- Describe your solution and some of its unique features
- Explain how your solution works
- Explain how your solution meets Mrs. Quek's needs
- Explain how your solution takes into consideration the following criteria: land area, manpower, and cost-effectiveness in monetary and energy costs

The group will record their feedback on your solution below:

Group Name: _____

A What do you like about their solution?

We like Responses may vary and are dependent on students' design and sharing. _____

_____

B What do you wish their solution had or could do?

We wish Responses may vary and are dependent on students' design and sharing. _____

_____

C How do you think their solution can be changed to better meet Mrs. Quek's needs?

We wonder Responses may vary and are dependent on students' design and sharing. _____

_____

Activity VII: Revise the Solution

D **Sketch**

Use the other group's feedback to revise your solution. Sketch your revised solution in the space provided below. Include diagrams or annotations to help others better understand how your solution works.

Students' ideas may vary.
Check that the drawing is detailed and labelled.

Sketching Area

How did you change your solution to better meet Mrs. Quek's needs? Explain it here.

Responses may vary and are dependent on students' design and sharing. _____

_____

_____

Activity VIII: Test the Solution, Part 2

Share your solution with the same group so they can give you feedback on your revised solution. When sharing your solution, you can:

- Describe what changes you made to your solution
- Explain why you made those changes
- Explain how your solution better meets Mrs. Quek's needs

The group will record their feedback on your solution below:

Group Name: _____

A What do you like about their solution?

We like Responses may vary and are dependent on students' design and sharing. _____

_____

_____

B What do you wish their solution had or could do?

We wish Responses may vary and are dependent on students' design and sharing. _____

_____

_____

C How do you think their solution can be changed to better meet Mrs. Quek's needs?

We wonder Responses may vary and are dependent on students' design and sharing. _____

_____

_____

Activity IX: Finalise the Solution

D **Sketch**

Use the other group's feedback to finalise your solution. Sketch your finalised solution in the space provided below. Include diagrams or annotations to help others better understand how your solution works.

Students' ideas may vary.
Check that the drawing is detailed and labelled.

Sketching Area

How did you change your solution to better meet Mrs. Quek's needs? Explain it here.

Responses may vary and are dependent on students' design and sharing. _____

_____

_____

Activity X: Build the Solution

Now that you've finalised your solution, let's build it! Select from the materials provided to build a 3-D model of your design. Only use the materials you need.

Activity XI: Share the Solution

You will share your solution with the rest of the class. You have 3 – 5 minutes to present your solution, followed by a 3-minute Q&A session. In your presentation, you should:

- Describe your solution and some of its unique features
- Explain how your solution works
- Explain how your solution meets Mrs. Quek's needs
- Explain how your solution takes into consideration the following criteria: land area, manpower, and cost-effectiveness in monetary and energy costs

Use the space below to make notes for your presentation.

Responses may vary and are dependent on students' design and sharing.

Presentation Notes

Activity XII: Reflect on the Solutions

Review the solutions for each group below, including your own.

Group Name: _____

A What do you like about the solution?

We like Responses may vary and are dependent on students' design and sharing. _____

_____

B What do you wish the solution had or could do?

We wish Responses may vary and are dependent on students' design and sharing. _____

_____

C How do you think the solution can be changed to better meet Mrs. Quek's needs?

We wonder Responses may vary and are dependent on students' design and sharing. _____

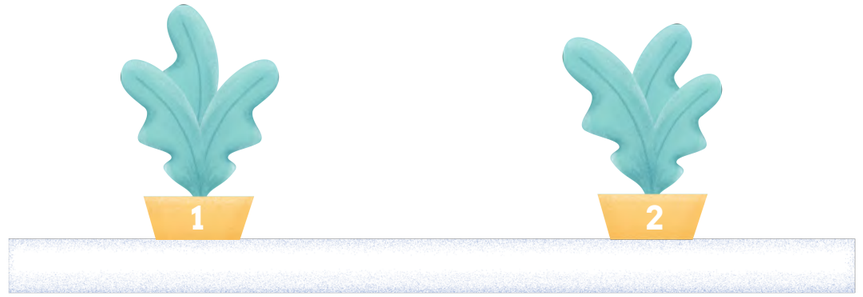
_____

– End of Urban Farming –

Vertical Farming

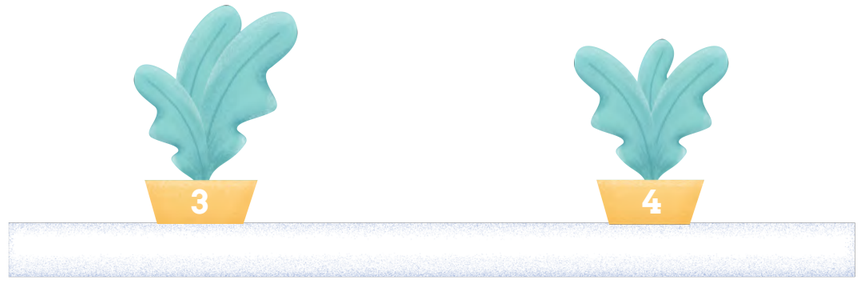
Activity Booklet

Group Name: _____ Date: _____



Name: _____ Name: _____

(Group Member 1) *(Group Member 2)*



Name: _____ Name: _____

(Group Member 3) *(Group Member 4)*

Name: _____ Name: _____

(Group Member 5) *(Group Member 6)*

Activity I: Understand the Need

LittleRedDot Secondary, a school in Singapore, is planning to build and upgrade some of its buildings and facilities. One of the facilities the school is planning to improve is its community garden.

Singapore needs to increase its local food production to ensure that its residents will have access to a reliable food supply in times of need, like in the current COVID-19 situation. The school fully supports Singapore's target to increase its production of food to meet the country's nutritional needs by 2030 from its current rate of 10% to 30%. To help Singapore meet its target, the school plans to redesign its community garden to support local farming and the school community.

The school has decided that vertical farming will be used for the community garden, and in a bid to promote a sustainable environment, it would like the design to incorporate the use of recyclable materials. Plastics are durable, light and versatile, but can take up to 400 years to decompose. This will affect people's lives for the next 16 generations. Hence, repurposing used plastic containers and other recyclable items in the community garden will be a small step towards sustainable farming.

The school has invited the students of LittleRedDot Secondary to participate in the redesign of the community garden. Students will share their solutions and submit potential designs for the school committee to consider.

As students of LittleRedDot Secondary, your group has been tasked to redesign the community garden as a space that will be able to produce local food to support the school community. The school is open to keeping the garden where it is or relocating it to another part of the school. Along with the incorporation of recyclable materials, you will need to consider the following constraints in your design:

1. **Land Area** – The school will allocate 1⁄2 hectare of land area (~ 1 football field) for the community garden. How can you optimize the space provided?
2. **Manpower** – As a community garden, there will be limited people tending to the garden. The school has a gardener on-site and students will tend to the plants on an ad-hoc basis.
3. **Cost-effectiveness** in Monetary and Energy Costs – To determine cost-effectiveness, you should consider the costs to initially build and maintain the community garden.

As a group, you are to present your recommended solution to the school committee.

Activity II: Identify the Need

What is the need to be addressed by your solution?

Activity III: Research the Solution

What is vertical farming and how does it work? What are the advantages and disadvantages of using vertical farming for the school community garden?

Type	How it works	Advantages	Disadvantages
Vertical Farming			

The school plans to use multiple 2m x 2m (2000mm x 2000mm) square stainless steel structures to act as the main support frame for vertical farming.

It will also provide plastics and other recyclable materials that can be used for the community garden.

Activity IV: Imagine the Solution

Design a solution that addresses the need (Activity II) and considers the constraints (Activity I) and what you have learned about vertical farming (Activity III). Again, the school is open to keeping the garden where it is or relocating it to another part of the school.

A Develop

What promising solutions can you come up with to address the need? The more solutions the better! Use the space below to sketch or write your solutions.

Development Area

Activity V: Plan the Solution

A Constraints

What does the solution need to have or do to address the need?

1 _____

_____

_____

2 _____

_____

_____

3 _____

_____

_____

4 _____

_____

_____

5 _____

_____

_____

B Select

Based on the criteria you listed, revisit your promising solutions to address the need. Select a solution to create.

1 _____

_____

Activity VI: Create the Solution

D Sketch

Use the space below to sketch your selected idea in detail. Include diagrams or annotations to help others better understand how your solution works.

Sketching Area

View of main support frame from different angles

How does your solution work? Explain it here.

_____

_____

Activity VII: Test the Solution, Part 1

Share your solution with one of the other groups so they can give you feedback. When sharing your solution, you can:

- Describe your solution and some of its unique features
- Explain how your solution works
- Explain how your solution addresses the need
- Explain how your solution takes into consideration the following constraints: land area, manpower, cost-effectiveness in monetary and energy costs, and incorporation of recyclable materials

The group will record their feedback on your solution below:

Group Name: _____

A What do you like about their solution?

We like _____

_____

B What do you wish their solution had or could do?

We wish _____

_____

C How do you think their solution can be improved to better address the need?

We wonder _____

_____

Activity VIII: Improve the Solution

D Sketch

Use the other group's feedback to improve your solution. Sketch your improved solution in the space provided below. Include diagrams or annotations to help others better understand how your solution works.

Sketching Area

View of main support frame from different angles

How did you improve your solution to better address the need? Explain it here.

_____

_____

_____

Activity IX: Test the Solution, Part 2

Share your solution with the same group so they can give you feedback on your improved solution. When sharing your solution, you can:

- Describe what improvements you made to your solution
- Explain why you made those improvements
- Explain how your solution better addresses the need

The group will record their feedback on your solution below:

Group Name: _____

A What do you like about their solution?

We like _____

_____

_____

B What do you wish their solution had or could do?

We wish _____

_____

C How do you think their solution can be improved to better address the need?

We wonder _____

_____

Activity X: Finalise the Solution

D Sketch

Use the other group's feedback to finalise your solution. Sketch your finalised solution in the space provided below. Include diagrams or annotations to help others better understand how your solution works.

Sketching Area

View of main support frame from different angles

How did you improve your solution to better address the need? Explain it here.

_____

_____

_____

Activity XI: Build the Solution

Now that you've finalised your solution, let's build it! Select from the materials provided to build a 3-D model of your design. Only use the materials you need.

Activity XII: Share the Solution

You will share your solution with the rest of the class. You have 3 – 5 minutes to present your solution, followed by a 3-minute Q&A session. In your presentation, you should:

- Describe your solution and some of its unique features
- Explain how your solution works
- Explain how your solution addresses the need
- Explain how your solution takes into consideration the following constraints: land area, manpower, cost-effectiveness in monetary and energy costs, and incorporation of recyclable materials

Use the space below to make notes for your presentation.

Presentation Notes

Activity XIII: Reflect on the Solutions

Review the solutions for each group below, including your own.

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be improved to better address the need?

We wonder _____

_____

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be improved to better address the need?

We wonder _____

_____

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be improved to better address the need?

We wonder _____

_____

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be improved to better address the need?

We wonder _____

_____

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be improved to better address the need?

We wonder _____

_____

Group Name: _____

A What do you like about the solution?

We like _____

_____

B What do you wish the solution had or could do?

We wish _____

_____

C How do you think the solution can be improved to better address the need?

We wonder _____

_____

– End of Activity Sheet –

Vertical Farming

Teachers' Notes

Stream	Topic	Estimated Duration
Express	Photosynthesis (Solution-centric)	6 hours

Aim(s)

At the end of the lesson, students should be able to:

Syllabus Learning Outcomes	• Explain the context of limited land space in Singapore. • Explain the problem of food sustainability in Singapore. • Research on vertical farming methods, discuss and decide on the design of the vertical farming system for the school community garden. • Sketch the design of the vertical farming system. • Build a model of their vertical farming system to show how it works. • Present a vertical farming system that addresses the need and constraints.
Engaging students in the Practices of Science	• WOTD: Design a vertical farming system that address a need and its constraints. Collect feedback to improve the design and consider the limitations of the design. • STSE: Scientific knowledge can be used to develop technologies.
Inculcating VEA	• Creativity: Innovate in developing a vertical farming system for the community garden to produce local food to support the school community.

Preparation Notes

Materials/Apparatus (1 set per group)

- Acrylic frame structure simulating stainless steel structure (1)
- Scaled-down planters (10)
- Glue gun (1)
- Glue sticks (5)
- Handheld drill (with twist drill bits of different diameters (2)
- Split pin (10)
- Masking tape, about 2 cm-thick (1 roll)
- Scissors (1)
- Metal wire (~1m)
- Ice cream sticks (20)
- Satay sticks (20)
- Aluminium foil, 30 cm by 30 cm (2 sheets)
- Bubble tea straws (10)
- Standard narrow straw, hard (20)
- Pen knife (1)
- Mounting board, A4 size (4)
- String (1 roll)
- Plastic mesh, 30cm x 70cm (1)
- 1.5L soft drink plastic bottle (2)
- Bean curd plastic bowl (2)
- Extra paper if needed for sketching, A3 size (2)
- Cutting matt (1)
- Wooden board (1) or newspaper for hot gluing
- Rulers for measurement

Materials/Apparatus (for a class)

- Stickers for groups to label their 3-D models
- Any recyclable materials the school thinks would be appropriate for the activity

Safety

Remind students to be careful when using sharp objects.

Suggested Lesson Guide

Prior knowledge: Students should be able to state the factors (light, water and carbon dioxide) needed for plants to conduct photosynthesis. They should also be able to describe the intake of carbon dioxide and water by plants.

Lesson Activity	Pedagogical Considerations
SESSION 1 *This activity is conducted individually.* **STEM Pre-Activity (15 mins)** 1. Issue STEM Pre-Activity Form to assess students' understanding on the concept of STEM and its applications to real-world problems. • If online, provide the link to the students • If paper-based, use the worksheet Minimise teacher facilitation. There should be no teacher facilitation if possible. **Design Pre-Activity (15 mins)** 1. Issue Design Activity Form to assess how students would respond to problems based on their prior knowledge and understanding of STEM. Minimise teacher facilitation. There should be no teacher facilitation if possible.	

Lesson Activity	Pedagogical Considerations
Introduce the Context (20 mins) 1. Show students the National Geographics' Food by the Numbers video (http://bit.ly/foodnumbers). 2. Using the PowerPoint slides and whole class question and answer, teach students that in Singapore, there is small land area and high competition for land use. You can link the video to the topic of food supply in Singapore. As much as possible, the context should be introduced to students via a class discussion. 3. By asking students to identify some uses of land in Singapore (eg. residential, industrial, urban use, etc.), this will help them realise the situation of high land competition and hence, a lack of land left for open-field farming. 4. Next, ask students how Singapore gets her supply of food. Students are expected to answer by saying that Singapore imports most of her food. If students struggle, you can ask additional questions such as, "Where do you think the Hokkaido milk (or any obvious food from abroad) sold in supermarkets come from?" 5. After identifying the fact that most food in Singapore is imported, ask students if they think that it is sustainable/advisable to import all food from other countries. The teacher can prompt students' response by giving the current COVID-19 situation where many severely affected countries are being	**Activating Prior Knowledge:** Students will have learned the factors needed for plants to conduct photosynthesis and the intake of carbon dioxide and water by plants during this process. It is useful to tap on this prior knowledge to check on their understanding and set the context for this **Setting the Context:** Context is important for students to understand the problem. It also helps students to appreciate the task by making it meaningful and relatable. Class discussion is more student-centered compared to a lecture. Hence it is advised for the introduction of the context to be in the form of a discussion. This allows the teacher to assess the students' level of

Lesson Activity	Pedagogical Considerations
locked down. Eg. What if Malaysia decides to stop its export of food and necessities to Singapore? This leads to the introduction of the problem of food self-sustainability in land-scarce Singapore. **Activity I: Understand the Need (20 mins)** 1. Get students to read the scenario in Activity 1. 2. Explain the scenario and task to students. 3. Scenario: To redesign the community garden as a space that will use an urban farming system to produce local food to support the school community. The school is open to keeping the garden where it is or relocating it to another part of the school. **Students' Task:** a. Develop an urban farming system for the community garden to produce local food to support the school community. b. Build a model of their solution using the materials provided. c. Share their solution with the rest of the class.	understanding, subsequently helping to fill the gaps in their understanding. **Setting the Context:** Context is important for students to understand the problem. It also helps students to appreciate the task by making it meaningful and relatable.

Lesson Activity	Pedagogical Considerations
Students will be given a set of constraints to consider in their solution: a. Optimise Land Area b. Optimise Manpower (less labour-intensive) c. Cost-effectiveness (Monetary and Energy Costs) d. Incorporation of recyclable materials Students need to keep in mind that no additional materials are allowed. If students' design involves technological elements, they do not need to build a fully functional technology. They only need to show on the model, how the technology will be built into their solution. *Activities II & III are conducted in groups.* **Activity II: Identify the Need (15 mins)** 1. Students identify the need to be addressed by their solution. **Activity III: Research the Solution (30 mins)** 1. Distribute the list of resources to each group and allocate time for students to review the resources. These resources are stimulus material on vertical farming.	**Supporting Self-Directed Learning:** Group discussion allows ideas to bounce off from one another as well as encourages students to ask more questions. **Supporting Self-Directed Learning:**

Lesson Activity	Pedagogical Considerations
2. Assign roles within the group for a more systematic discussion to take place. You may consider the following suggested roles (there could be variation depending on number of students per group): • Three students to review the provided resources. • One student to search for more information online. • Assign group member to act as note-taker to consolidate information obtained from the provided resources and additional information. Students will discuss their findings after reviewing the resources and additional information. Space is provided in the activity booklet for the note-taker to record the group's notes about vertical farming and the advantages and disadvantages of using this method for the school community garden. Activity IV is conducted in groups. The teachers should walk around the classroom to facilitate the discussion. The teacher can ask guiding questinos to help students better satisfy the criteria and consider what nutrients and factors are required for optimal plant growth.	Allowing students to research the topic will help them when they develop their solution. By learning about existing vertical farming methods, students can better understand what strategies are being adopted.
Activity IV: Imagine the Solution (15 mins) 1. Students begin the process of imagining possible	**Empowering learners:** Students are given the

Lesson Activity	Pedagogical Considerations
solutions to address the need. Space is provided in the activity booklet for students to sketch or write their solutions. **Activity V: Plan the Solution (15 mins)** 1. Students identify the constraints that their solution needs to overcome to address the need and select the promising solution they want to pursue as their solution. **Conclusion (5 mins)** 1. Conclude the lesson by telling students the agenda for the next lesson: groups will continue to create and build a solution to address the need they identified. **Collect Activity Booklets** 1. Collect all activity booklets at the end of the Session 1. They will be used during Session 2 **SESSION 2** **Briefing (5 mins)** 1. Brief students on the day's agenda: • All students will continue to create their solution though a process of developing, seeking feedback on, and improving their solution. • Students will build a 3-D model of their solution using basic materials.	autonomy to decide on the design of their vertical farming system. **Supporting Self-Directed Learning:** Allowing students to identify the constraints they will have to address and select the best solution to address these constraints will help them in the design of their vertical farming system.

Lesson Activity	Pedagogical Considerations
Activities VI - XI are conducted in groups. The teacher should walk around the classroom to facilitate the discussion. The teacher can ask guiding questions to help students better address the constraints and consider what nutrients and factors are required for optimal plant growth.	
Activity VI: Create the Solution (20 mins)	**Empowering learners:**
1.Students need to bear in mind the need and constraints that their solution will address as they decide on the structure and features of their solution. They should sketch their solution. The drawing should be detailed and labelled so that they can refer to the drawing when showing their sketch to others. They should also explain how their solution works.	Students are given the autonomy to negotiate the design of their urban farming system.
Space is provided in the activity booklet for students to sketch their idea. If they need more space, they can ask the teacher for A3 paper to draw their solution.	
Activity VII: Test the Solution, Part 1 (15 mins)	**Facilitating Collaborative Learning and Providing Feedback:**
1. Students seek feedback from another group by sharing their solution. They should show their sketch. They can also consider sharing the following:	Allowing students to gather input from their peers supports the active construction of ideas. It allows students to learn from each other to make improvements

Lesson Activity	Pedagogical Considerations
• Describing their solution and some of its unique features. • Explaining how their solution works. • Explaining how their solution addresses the need. • Explaining how their solution takes the constraints into consideration in its design.	to their vertical farming system.
Space is provided in the activity booklet for the other group to write down their feedback.	
Activity VIII: Improve the Solution (15 mins)	**Supporting Self-Directed Learning:**
1. Students should use the feedback they received to decide how to improve their solution. They should sketch their improved solution. The drawing should be detailed and labelled so that they can refer to the drawing when showing their sketch to others. They should also explain how they improved their solution to better address the need.	Allowing students to think about their peers' feedback provides opportunities to develop reflective thinking in how they can make improvements to their vertical farming system.
Space is provided in the activity booklet for students to sketch their idea. If they need more space, they can ask the teacher for A3 paper to draw their solution.	
Activity IX: Test the Solution, Part 2 (15 mins)	**Facilitating Collaborative Learning and Providing Feedback:**
1. Students seek feedback from the same group by sharing their improved solution. They should show	

Lesson Activity	Pedagogical Considerations
their sketch. They can also consider sharing the following: • Describing what improvements they made to their solution. • Explaining why they made those improvements. • Explaining how their solution better addresses the need. Space is provided in the activity booklet for the other group to write down their feedback. **Activity X: Finalise the Solution (10 mins)** 1. Students should use the feedback they received to decide on their finalised solution and sketch their idea. The drawing should be detailed and labelled so that they can refer to the drawing when showing their sketch to others. They should also explain how they improved their solution to better address the need. Space is provided in the activity booklet for students to sketch their idea. If they need more space, they can ask the teacher for A3 paper to draw their idea.	Allowing students to gather input from their peers supports the active construction of ideas. It allows students to learn from each other to make improvements to their vertical farming system. **Supporting Self-Directed Learning:** Allowing students to think about their peers' feedback provides opportunities to develop reflective thinking in how they can make improvements to their vertical farming system.

Lesson Activity	Pedagogical Considerations
Activity XI: Build the Solution (30 mins) 1. Inform students that they will be provided a set of materials which they can choose from to build their solution. They only need to build the structure of their model. If the model involves technological elements that are not able to be shown using the given materials, students can show how the technology will be incorporated and explain verbally during their presentation. If the farming system involves multiple replicates of the same structure, students will only have to build one of the replicates. 2. Issue materials to each group so that students can build their solution. 3. Walk around the classroom to facilitate the discussion. • In addition to asking guiding questions to help students better address the constraints and consider what nutrients and factors are required for optimal plant growth, you can also guide students on how to make use of the provided materials.	**Empowering learners:** Students are given the autonomy to decide on the choice of materials to be used for the 3D-model of their vertical farming system. Having a model helps each group to judge the feasibility of the physical structure of their design. They would have time to test out the general structure and modify their design.

Lesson Activity	Pedagogical Considerations
Conclusion (5 mins) 1. Conclude the lesson by telling students the agenda for the next lesson: groups will need to finish building their model and prepare for their sharing session. **Collect Activity Booklets and 3-D Models** 1. Collect all activity booklets and 3-D models the end of Session 2. They will be used during Session 3.	

Lesson Activity	Pedagogical Considerations
SESSION 3 **Briefing (5 mins)** 1. Brief students on the day's agenda: • All groups will continue to build their solution. • All groups will share their solution with the rest of the class. *Activities XI - XIII are conducted in groups.* **Activity XI (cont'): Build the Solution (30 mins)** 1. Students are to continue building their model. Students should label their 3-D models so that they cna refer to it during the sharing session. 2. Walk around the classroom to facilitate the discussion. • In addition to asking guiding questions to help students better satisfy the criteria and consider what nutrients and factors are required for optimal plant growth, you can also guide students on how to make use of the provided materials. **Activity XII: Share the Solution (20 mins)** 1. Students prepare their presentation to share their solution with the rest of the class.	**Empowering learners:** Students are given the autonomy to decide on the choice of materials to be used for the 3D-model of their vertical farming system. Having a model helps each group to judge the feasibility of the physical structure of their design. They would have time to test out the general structure and modify their design. **Supporting Self-Directed Learning:** Group discussion allows

Lesson Activity	Pedagogical Considerations
Students should include the following points in their presentation: • Describe their solution and some of its unique features. • Explain how their solution works. • Explain how their solution addresses the need. • Explain how their solution takes the constraints into consideration in its design. Space is provided in the activity booklet for students to make notes for the presentation. **Activity XII: Reflect on the Solutions (1 hr)** 1. Inform students that all groups should participate when they present their model. They should show their 3-D model in their presentation. 2. Inform students that they should listen as each group presents its solution. They are to write down their reflection of each solution, including their own. While each group is presenting, the audience should be focused and attentive. The audience also needs to reflect on the presenting group's solution. You are to guide the students in reflecting on the solutions. Questions raised should be specific to the particular solution and presentation. You can use the following guiding questions to help students narrow down their questions:	ideas to bounce off from one another as well as encourages students to ask more questions. **Facilitating Collaborative Learning and Providing Feedback:** Allowing students to gather input from their peers supports the active construction of ideas. It allows students to learn from each other to make improvements to their vertical farming system. **Supporting Self-Directed Learning:** Allowing students to think about their peers' feedback provides opportunities to

Lesson Activity	Pedagogical Considerations
• From the group's presentation, do you think they have addressed the need? If yes/ no, how so? • Which constraints do you think the group addressed in their solution? How did they do it? • Do you think that their solution will be able to produce enough food to support the school community? Why/why not? • How do you think the solution will work if it is implemented in the school? Do you foresee any potential problems that may arise from this solution? The reflection will take place after each presentation. Space is given in the activity booklet for students to write down their reflections. **Conclusion (5mins)** 1. Students label their 3-D models with their class and group name. 2. Conclude the lesson by summarising the activities that students have undergone for the past three sessions.	develop reflective thinking in how they can make improvements to their vertical farming system.urban farming system. **Supporting Self-Directed Learning:** Group discussion allows ideas to bounce off from one another as well as encourages students to ask more questions.

References

Food by the Numbers

• http://bit.ly/foodnumbers
(links to https://www.youtube.com/watch?v=CB9Enh6yP0w)

Vertical Farming

• http://bit.ly/doesverticalfarmingwork
(links to https://www.youtube.com/watch?v=dnCQuwCtqJg)

• http://bit.ly/SGVerticalFarming
(links to https://www.youtube.com/watch?v=cY7O5YNxKuI)

• http://bit.ly/VerticalFarmingInnovations
(links to https://interestingengineering.com/13-vertical-farming-innovations-that- could-revolutionize-agriculture)

• https://www.citiponics.com/

Creators of this lesson (if any)

Names of teachers involved in the creation	Pedagogical Considerations

– End of Teachers' Notes –

Vertical Farming

Annex A: Suggested Answers

As students of LittleRedDot Secondary, your group has been tasked to redesign the community garden as a space that will be able to produce local food to support the school community. The school is open to keeping the garden where it is or relocating it to another part of the school. Along with the incorporation of recyclable materials, you will need to consider the following constraints in your design:

1. **Land Area** – The school will allocate ½ hectare of land area (~ 1 football field) for the community garden. How can you optimize the space provided?
2. **Manpower** – As a community garden, there will be limited people tending to the garden. The school has a gardener on-site and students will tend to the plants on an ad-hoc basis.
3. **Cost-effectiveness** in Monetary and Energy Costs – To determine cost-effectiveness, you should consider the costs to initially build and maintain the community garden.

As a group, you are to present your recommended solution to the school committee.

Activity II: Identify the Need

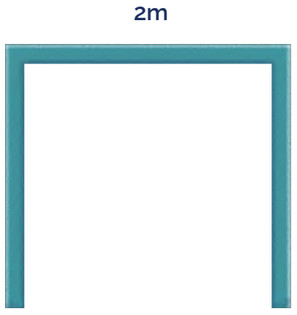
What is the need to be addressed by your solution?

Accept any reasonable response.

Activity III: Research the Solution

What is vertical farming and how does it work? What are the advantages and disadvantages of using vertical farming for the school community garden?

Type	How it works	Advantages	Disadvantages
Vertical Farming	Planning crops/ plants in vertical structures with aeration and sometime artificial light. Accept any other reasonable response.	Less land is required. Different crops can be grown in the same vertical structure. Accept any other reasonable response.	Need to build upwards hence likelihood of toppling accidents is higher. The amount of light that the plants are exposed to is uneven. Accept any other reasonable response.



The school plans to use multiple 2m x 2m (2000mm x 2000mm) square stainless steel structures to act as the main support frame for vertical farming.

It will also provide plastics and other recyclable materials that can be used for the community garden.

Activity IV: Imagine the Solution

Design a solution that addresses the need (Activity II) and considers the constraints (Activity I) and what you have learned about vertical farming (Activity III). Again, the school is open to keeping the garden where it is or relocating it to another part of the school.

A Develop

What promising solutions can you come up with to address the need? The more solutions the better! Use the space below to sketch or write your solutions.

Students' ideas may vary.

Notes:

Development Area

Activity V: Plan the Solution

A Constraints

What does the solution need to have or do to address the need?

1. Accept any reasonable response (for example, collection of stagnant water, light is blocked, watering plant is difficult etc.).
2. Accept any reasonable response.
3. Accept any reasonable response.
4. Accept any reasonable response.
5. Accept any reasonable response.

B Select

Based on the criteria you listed, revisit your promising solutions to address the need. Select a solution to create.

1 Responses may vary and are dependent on students' design.

Activity VI: Create the Solution

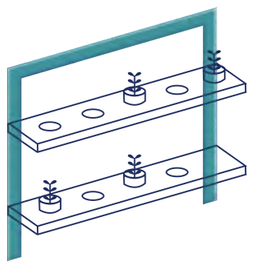
D Sketch

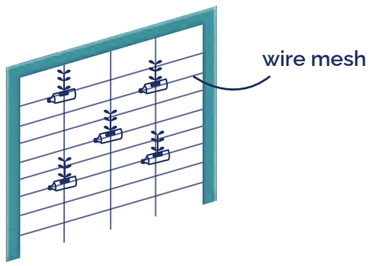
Use the space below to sketch your selected idea in detail. Include diagrams or annotations to help others better understand how your solution works.

Students' ideas may vary.
Check that the drawing is detailed and labelled.

Sketching Area

Examples:





How does your solution work? Explain it here.

Responses may vary and are dependent on students' design.

Activity VII: Test the Solution, Part 1

Share your solution with one of the other groups so they can give you feedback. When sharing your solution, you can:

- Describe your solution and some of its unique features
- Explain how your solution works
- Explain how your solution addresses the need
- Explain how your solution takes into consideration the following constraints: land area, manpower, cost-effectiveness in monetary and energy costs, and incorporation of recyclable materials

The group will record their feedback on your solution below:

Group Name: _____

A What do you like about their solution?

We like Responses may vary and are dependent on students' design and sharing.

B What do you wish their solution had or could do?

We wish Responses may vary and are dependent on students' design and sharing.

C How do you think their solution can be improved to better address the need?

We wonder Responses may vary and are dependent on students' design and sharing.

Activity VIII: Improve the Solution

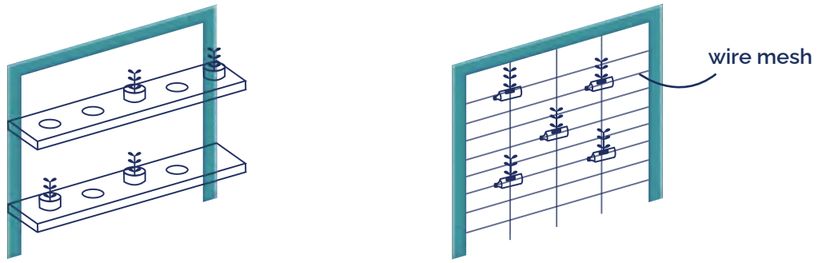
D Sketch

Use the other group's feedback to improve your solution. Sketch your improved solution in the space provided below. Include diagrams or annotations to help others better understand how your solution works.

Students' ideas may vary.
Check that the drawing is detailed and labelled.

Sketching Area

Examples:



How did you improve your solution to better address the need? Explain it here.

Responses may vary and are dependent on students' design.

Activity IX: Test the Solution, Part 2

Share your solution with the same group so they can give you feedback on your improved solution. When sharing your solution, you can:

- Describe what improvements you made to your solution
- Explain why you made those improvements
- Explain how your solution better addresses the need

The group will record their feedback on your solution below:

Group Name: _____

A What do you like about their solution?

We like Responses may vary and are dependent on students' design and sharing.

B What do you wish their solution had or could do?

We wish Responses may vary and are dependent on students' design and sharing.

C How do you think their solution can be improved to better address the need?

We wonder Responses may vary and are dependent on students' design and sharing.

Activity X: Finalise the Solution

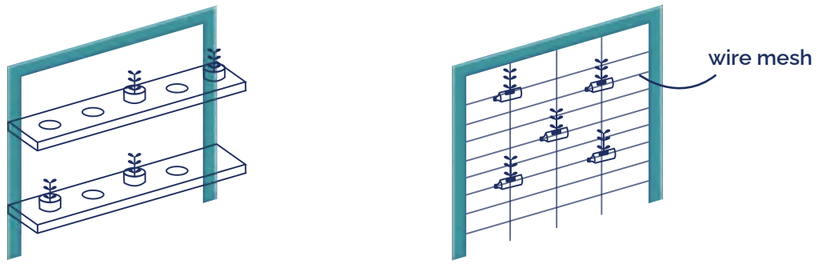
D Sketch

Use the other group's feedback to finalise your solution. Sketch your finalised solution in the space provided below. Include diagrams or annotations to help others better understand how your solution works.

Sketching Area

Students' ideas may vary.
Check that the drawing is detailed and labelled.

Examples:



How did you improve your solution to better address the need? Explain it here.

Responses may vary and are dependent on students' design.

Activity XI: Build the Solution

Now that you've finalised your solution, let's build it! Select from the materials provided to build a 3-D model of your design. Only use the materials you need.

Activity XII: Share the Solution

You will share your solution with the rest of the class. You have 3 – 5 minutes to present your solution, followed by a 3-minute Q&A session. In your presentation, you should:

- Describe your solution and some of its unique features
- Explain how your solution works
- Explain how your solution addresses the need
- Explain how your solution takes into consideration the following constraints: land area, manpower, cost-effectiveness in monetary and energy costs, and incorporation of recyclable materials

Use the space below to make notes for your presentation.

Presentation Notes

Responses may vary and are dependent on students' design and sharing.

Activity XIII: Reflect on the Solutions

Review the solutions for each group below, including your own.

Group Name: _____

A What do you like about the solution?

We like Responses may vary and are dependent on students' design and sharing.

_____

B What do you wish the solution had or could do?

We wish Responses may vary and are dependent on students' design and sharing.

_____

C How do you think the solution can be improved to better address the need?

We wonder Responses may vary and are dependent on students' design and sharing.

_____

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