Cross-curricular Project Learning for STEM Education

Level： KS3 - Secondary One
Project: An environmental friendly greenhouse

Scenario:
Students are requested to build a model of an environmental friendly greenhouse for which the user can create an environment with adjustable temperature/humidity to facilitate the growth of plants.

Flexible Implementation Modes:
(i) Aligning teaching elements of STEM Subjects;
(ii) Collaboration among STEM Subjects; or
(iii) STEM Week.

(A) Key Features

In this project learning activity, students are expected to integrate and apply knowledge and skills from Science, Technology and Mathematics (STEM) Education through a hands-on design project, which may include the following learning elements from STEM subjects:

<u>Science</u>
- Understand the essential living conditions of growing plants
- Understand and utilise natural resources in daily life, such as solar and water
- Understand the concepts of energy changes, heat transfer and water conservation
- Verify assumptions and design concepts through Investigation and experiments

<u>Technology</u>
- Understand and utilise stable structure in the design and construction of green house
- Understand and construct simple circuit for electrical appliances
- Use tools, machines and equipment to process appropriate materials
- Understand CAD and CAM (3D printing) through design and make of 3D components for the greenhouse

<u>Mathematics</u>
- Understand and apply mathematical concepts and skills to solve scientific and technological problems, such as finding surface areas and volumes, and plotting graphs

(B) Prerequisite Knowledge in General Studies and Mathematics at Primary School

The Greenhouse project is designed for S1 students to integrate their STEM knowledge and skills without requiring sophisticated technological skills and advanced scientific knowledge. However, the following prerequisite knowledge and skills from the KS1 and KS2 could help S1 students to scaffold their learning to the expected learning outcomes.

	General Studies	Mathematics
KS1	• Common materials	• Calculates the perimeter and area of the polygon • Read and create line charts • Use the cuboid volume formula • Understanding cylinder and cone
KS2	• Testing of shower head • Essential elements for growing plants • The design of skyscraper	

(A) Task Definition

Through an integrated project approach, connected learning tasks could be organised to apply essential knowledge, concepts and skills from STEM subjects in an authentic context. A wide variety of learning tasks suggested for STEM subjects which students can work together in groups, including:

<u>Scientific Investigations and Exploration</u>

- Devise water-conserving methods for irrigation of the plants in the greenhouse
- Conduct fair tests to explore ways to maintain the temperature/humidity in the greenhouse
- Investigate how the orientation of the solar panels affects the electrical power generated for use by the exhaust fan in the greenhouse

<u>Design and Make</u>

- Design and make a greenhouse model with wood strips and polycarbonate sheets
- Design and make a solar powered exhaust fan to control the temperature/humidity inside the greenhouse
- Design and make a rain water collection, storage and pumping system for watering the plants
- Design and make the required components/parts for the greenhouse with 3D CAD software and 3D printer
- Test the structure and functions of the greenhouse

Problem Solving with Mathematical Skills

- Investigate the surface areas of greenhouses having the same volume but of different shapes
- Calculate the amount of materials needed for building the greenhouse model
- Draw figures and graphs to present data collected, e.g. temperature, humidity

(B) Relevant Learning Elements in STEM Subjects

When engaging in this project learning activity, students will require the following learning elements from STEM subjects, teachers may need to adjust the teaching sequence to facilitate the project learning activities.

Science	Technology	Mathematics
● Water purification ● Water conservation and pollution ● Energy sources: solar energy ● Energy: forms, conversion, conservation ● Heat transfer: conduction, convection and radiation ● Science process skills (e.g. designing investigations, conducting practical, inferring, communicating)	● Design process and design considerations ● Appropriate choice and use of materials and structures ● Appropriate choice and use of tools and equipment ● Electrical control system and devices ● Computer-aided manufacturing : 3D Printing ● Information processing and information processing tools	● Finding surface areas and volumes, i.e. amount of materials needed ● Presenting the design using 3-D drawings ● Plotting graphs of temperature of the greenhouse against time

(C) Intended STEM Learning Tasks Outcomes

This STEM project is intended to integrate and apply essential knowledge, concepts and skills from STEM subjects in an authentic learning experience, the following outcomes/products could be achieved:

Scientific Investigation	Design and Making	Problem Solving with Mathematical Skills
● Scientific investigation/ testing report on: ▶ ways to conserve water in daily use ▶ possible means to purify muddy water ▶ factors affecting conduction, convection and radiation ▶ ways to keep the temperature constant ▶ efficiency of electricity generated with a solar cell	● A functional greenhouse model with a solar powered exhaust fan to control the temperature ● A rain water collection and purification sub-system for watering the plants	● A greenhouse design having a reasonable ratio of volume to material consumption ● Figures and presentation charts of experiment results

(D) Flexible Implementation Modes

This STEM project could be implemented according to school's unique situation and curriculum setting; individual school could consider the following modes of implementation.

Mode 1 – **<u>Aligning teaching elements of STEM Subjects</u>**

Teaching sequence of related topics in STEM subjects are aligned within a certain period of a school term to facilitate the scaffolding of essential concepts.

Week	Science lessons	Technology lessons	Mathematics lessons
1 – 6	● Explore ways to conserve water in daily use ● Explore possible means to purify muddy water ● Conduct investigations on factors affecting conduction, convection and radiation ● Explore ways to keep the temperature constant ● Generate electricity using a solar cell		

Week	Science lessons	Technology lessons	Mathematics lessons
7			• Investigate the surface areas of greenhouses having the same volume but of different shapes • Calculate the amount of materials needed for building the greenhouse model • Drawing figures and graphs to present data collected
8 - 12		• Design and make a greenhouse model with wood strip and polycarbonate sheet • Design and make a solar powered exhaust fan to control the temperature inside the greenhouse • Design and make a rain water collection and purification system for watering the plants • Design and make the required components with 3D CAD software and 3D printer	
13	• Realisation and evaluation of greenhouse design, including: ▶ Scientific investigation/testing report with surveys and presentation charts; and ▶ A functional greenhouse model.		

Mode 2 – **<u>Collaboration among STEM Subjects</u>**

Learning and teaching of related topics in STEM subjects commence concurrently in order to facilitate the integration of knowledge and skills collaboratively.

<table>
<tr><th>Week</th><th>Science lessons</th><th>Technology lessons</th><th>Mathematics lessons</th></tr>
<tr><td>1 - 8</td><td>● Explore ways to conserve water in daily use
● Explore possible means to purify muddy water
● Conduct investigations on factors affecting conduction, convection and radiation
● Explore ways to keep the temperature constant
● Generate electricity using a solar cell</td><td>● Design and make a greenhouse model with wood strip and polycarbonate sheet
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<tr><td>9 - 16</td><td></td><td></td><td></td></tr>
<tr><td>17 - 22</td><td colspan="3">● Realisation and evaluation of greenhouse design, including:
► Scientific investigation/testing report with surveys and presentation charts; and
► A functional greenhouse model.</td></tr>
</table>

Mode 3 – **STEM Week**

Learning activities in STEM subjects were fully integrated as a holistic learning experience within a week.

Day 1	Day 2	Day 3	Day 4 - 5
● Introduction and information search ● **[SE]** Explore ways to conserve water in daily use ● **[TE]** Design and make a greenhouse model with wood strip and polycarbonate sheet ● [**ME]** Investigate the surface areas of greenhouses having the same volume but of different shapes	● **[SE]** Explore possible means to purify muddy water ● **[SE]** Conduct investigations on factors affecting conduction, convection and radiation ● **[TE]** Design and make a rain water collection and purification system for watering the plants ● **[ME]** Calculate the amount of materials needed for building the greenhouse model	● **[SE]** Explore ways to keep the temperature constant ● **[SE]** Generate electricity using a solar cell ● **[TE]** Design and make a solar powered exhaust fan to control the temperature inside the greenhouse ● **[TE]** Design and make the required components with 3D CAD software and 3D printer ● **[ME]** Drawing figures and graphs to present data collected	● Realisation and evaluation of greenhouse design, including: ▶ **[SE] [ME]** Scientific investigation/ testing report with surveys and presentation charts; ▶ **[TE]** A functional greenhouse model.

Remarks: *[SE]: Science Education; [TE]: Technology Education; and [ME]: Mathematics Education.*

(E) Notes to the Teachers

The implementation of STEM project is a new initiative to schools which requires substantial support and joint effort from various stakeholders. Teachers should be aware of the following areas when devising STEM project in school:

- Teachers' readiness for collaboration and acquiring new skills;
- Engaging students' learning, with authentic learning experience;
- Schools offer an open and flexible curriculum framework and implementation modes;
- Resources available including makers' space and resources materials; and
- Stakeholders' support and involvement.