Science (S1-3) STEAM Learning Module –

Engineering Practices

Science Education Section

Curriculum Support Division

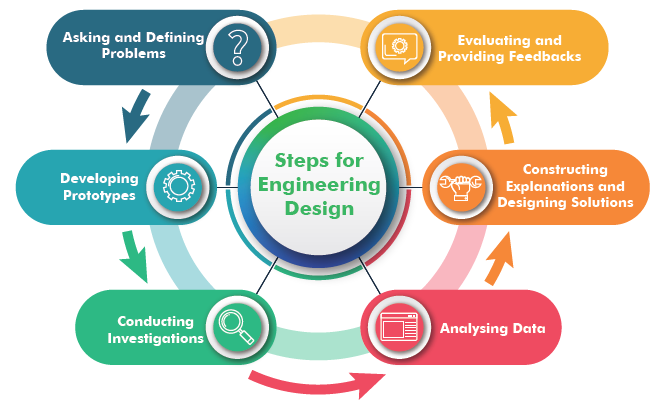
Education Bureau, HKSAR

2023

# Notes for Teachers

**Conducting Science (S1-3) Learning Activities on Engineering Practices**

In the course of science learning at junior secondary level, students will conduct a number of engineering-related learning activities (i.e. ‘Design and Make’). An important aim for conducting these activities in science lessons is to facilitate students to experience engineering practices through ‘hands-on, minds-on’ learning activities. It is expected that students will learn about the knowledge and skills required in performing engineering design, developing prototypes and solving engineering problems. The steps for conducting engineering design are described in the diagram below :



Although engineering design is similar to scientific investigation in many ways on aspects such as conducting investigations, analysing data and constructing explanations, there are differences in some other aspects. For example, scientific investigation involves the formulation of hypothesis and examining it through conducting experiments, while engineering designs involves defining an engineering problem and solving it through prototyping and testing.

**The Learning and Teaching Activities**

This learning module includes engineering design and problem solving activities, which are linked to topics covered in Junior Secondary (JS) Science. These activities facilitate students to solve daily-life problems by experiencing steps for engineering design, through which students can learn about different aspects such as defining questions, developing prototypes and conducting investigation. Relevant learning and teaching activities are outlined below :

|  |  |  |
| --- | --- | --- |
|  | **Learning activities** | **Topics related to**  **JS Science** |
| Problem Solving Activities | Analysis on the Efficiency of Different Water Purification Methods | Methods of  water purification |
| Engineering Considerations on Installing Solar Power Systems | Renewable energy |
| Engineering Design of  Tsing Ma Bridge | Thermal expansion and contraction  The properties of metals |
| Engineering Design | Design and Make  a Temporary House for a Puppy | Heat transfer |
| Design and Make  a Water Treatment Device | Methods of  water purification |

Teachers can use scaffolding learning, or other learning and teaching strategies as appropriate, to facilitate students to learn about engineering practices in the activities.

Teachers can conduct ‘Problem-solving Activity’ science lessons for students to introduce concepts about Engineering Practices in the first place, and provide more guidance for students to understand the knowledge of engineering practices.

After students have acquired basic understanding about engineering practices, teachers can arrange ‘Engineering Design Activities’ for student groups, and allow rooms for students to propose designs on their own, develop their own solutions in tackling the engineering problems, build the prototypes and conduct scientific tests.

Alternatively, teachers can use the portfolio template included in this learning module as a tool to guide students to conduct other suitable ‘Design and Make’ Activities.

The learning elements involved in engineering design are tabulated below for teachers’ reference :

|  |  |  |  |
| --- | --- | --- | --- |
| **Engineering Design procedures** | **Elements of Engineering Practices** | **Engineering Design Activity** | **Problem-solving Activity** |
| Asking and Defining Problems | Identify Engineering Problems | **•** | **•** |
| Identify constraints and find out criteria to achieve the expected outcome | **•** | **•** |
| Consider the needs of users and the expectations from the stakeholders | **•** | **•** |
| Developing Prototypes | Propose different designs | **•** |  |
| Recognise the advantages and limitations of the proposed designs | **•** |  |
| Conducting Investigations | Conduct scientific tests and summarise data about the performance of the proposed designs under a range of conditions | **•** |  |
| Analysing Data | Analyse data for the optimal setting of the proposed designs | **•** | **•** |
| Conduct budget calculation | **•** | **•** |
| Constructing Explanations and Designing Solutions | Evaluate and select the best design with reference to different criteria | **•** | **•** |
| Evaluating and Providing Feedbacks | Present the advantages and the limitations of the finalised design | **•** |  |
| Analyse the feedbacks received and propose further enhancement to the design | **•** |  |

# Problem-solving Activities

# Activity 1 Analysis on the Efficiency of Different Water Purification Methods

|  |  |
| --- | --- |
| Relevant Topics in  Junior Secondary Science | * Methods of Water Purification |

The diagram below shows an experiment conducted to test the filtration performance of three different materials (A, B and C) using a filtration setup.

|  |  |  |
| --- | --- | --- |
|  | Filtration Setup | |
| Material (A, B or C) | |
| Time required for the filtration (mins) | Cloudiness of the filtrate  (NTU) |
| Material A | 2 | 0.82 |
| Material B | 4 | 0.41 |
| Material C | 7 | 0.12 |

**1** Write the independent variable(s), dependent variable(s) and control variable(s) of the experiment.

|  |  |
| --- | --- |
| Independent variable(s) | Three different materials |
| Dependent variable(s) | Cloudiness of the filtrate,  time required for the filtration |
| Control variable(s) | Volume of muddy water, mass of three materials |

**2** With reference to the information given, which materials (A, B or C) are the most suitable for filtering muddy water?

Material C is the most suitable for filtering muddy water. Although the time required for the filtration is the longest among the tests, the cloudiness of the filtrate obtained is the lowest one.

**3** The cost for the materials are shown below :

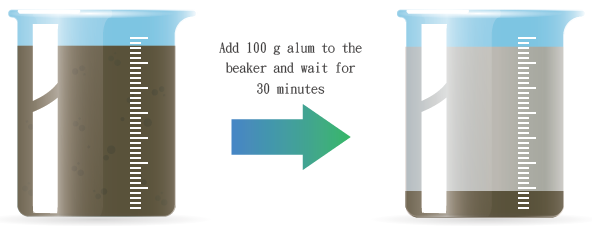
|  |  |
| --- | --- |
| Material | Cost ($ / 100 g) |
| A | $ 10.7 |
| B | $ 41.6 |
| C | $ 45.2 |

A user wish to develop a filtration system which can produce filtrate with cloudiness lower than 0.5 NTU.

Explain which materials would suit the usage the best.

|  |
| --- |
| Answer :  Teachers can discuss with students the choice of materials which could suit the best with reference to different factors, such as the cloudiness of filtrate, the cost of the materials, the time required for the filtration, the volume of muddy water required, and the usage of the filtration system. |

**4** Alum can also be used to make the muddy water less cloudy.



|  |  |  |  |
| --- | --- | --- | --- |
| Material | Time required for obtaining the purified water (min / L) | Cloudiness of purified water  (NTU) | Cost  ($ / 100 g) |
| Alum | 30 | 0.08 | $ 242.2 |

With reference to the information above, compare the use of alum for purifying muddy water and the filtration methods with the use of materials A, B and C. Write TWO advantages and TWO limitations of using alum for purifying muddy water.

|  |  |
| --- | --- |
| **Advantages** | **Limitations** |
| Using alum for purifying muddy water will produce water with cloudiness lower than that using other filtration methods. | The cost for using alum to purify muddy water is more expensive than that using other filtration methods. |
| The method of purification using alum is simpler.  (Note : Decantation is required for obtaining purified water.) | The time required for the purification using alum is longer than that using other filtration methods. |

# Activity 2 Engineering Considerations on Installing Solar Power Systems

|  |  |
| --- | --- |
| Relevant Topics in  Junior Secondary Science | * Renewable energy |

Installing solar power systems on the roof top of a building is a renewable way to generate electricity.

**Situation**

An engineer project is going to install solar power systems on the roof top of two buildings.

The following shows some information of different engineering solutions :

|  |  |  |  |
| --- | --- | --- | --- |
| Engineering solutions | Installation cost per system ($) | The highest power output (kW) | Area (m2) |
| A | 70 000 | 2.0 | 15.0 |
| B | 150 000 | 4.0 | 23.0 |
| C | 90 000 | 2.7 | 15.0 |
| D | 130 000 | 3.7 | 26.0 |

For each of the cases below, suggest which engineering solutions (A, B, C or D) you would recommend. Explain your answer in the space below.

**1 The requirement for installing solar power system on building X :**

* The space available for installing the solar power system is about 30 m2
* To harvest as most energy as possible regardless of the cost

[Remarks : Teachers could make changes to the requirement for adjusting the difficulty of the task]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Recommendation :  (Teachers may guide students to build an analysis grid (shown in the table below), and discuss with students the best solution for installing solar power system having regard to different factors.)   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Engineering solutions | The no. of systems to be installed | The highest power output (kW) | Space occupied (m2) | Cost ($) | | A | 2 | 2.0 × 2 = 4 | 15 × 2 = 30 | 70 000 × 2 = 140 000 | | B | 1 | 4.0 × 1 = 4 | 23 × 1 = 23 | 150 000 × 1 = 150 000 | | C | 2 | 2.7 × 2 = 5.4 | 15 × 2 = 30 | 90 000 × 2 = 180 000 | | D | 1 | 3.7 × 1 = 3.7 | 26 × 1 = 26 | 130 000 × 1 = 130 000 | |

**2 The requirement for installing solar power system on building Y :**

* The space available for installing the solar power system is about 25 m2
* To harvest as most energy as possible within the cost of installation work not exceeding $ 200 000

[Remarks : Teachers could make changes to the requirement for adjusting the difficulty of the task]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Recommendation :  (Teachers may guide students to build an analysis grid (shown in the table below), and discuss with students the best solution for installing solar power system having regard to different factors.)   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Engineering solutions | The no. of systems to be installed | The highest power output (kW) | Space occupied (m2) | Cost ($) | | A | 1 | 2.0 × 1 = 2 | 15 × 1 = 15 | 70 000 × 1 = 70 000 | | B | 1 | 4.0 × 1 = 4 | 23 × 1 = 23 | 150 000 × 1 = 150 000 | | C | 1 | 2.7 × 1 = 2.7 | 15 × 1 = 15 | 90 000 × 1 = 90 000 | | D | 1 | 3.7 × 1 = 3.7 | 26 × 1 = 26 | 130 000 × 1 = 130 000 | |

# Activity 3 Engineering Design of the Tsing Ma Bridge

|  |  |
| --- | --- |
| Relevant Topics in  Junior Secondary Science | * Thermal expansion and contraction * The properties of metals |

The Tsing Ma Bridge is a vital component of the transport network connecting the urban area and the Hong Kong International Airport.

There are different design features which enable the Tsing Ma Bridge to resist damage due to environmental factors.

**1** The following figures show the connection joints between parts of the Tsing Ma Bridge. There are some gaps in the connection joints and this design could help preventing damages on the bridge during hot summer time.

**(a) (i)** The following shows a concept diagram to describe a part of bridge during winter time.

|  |
| --- |
| Winter time (10oC) |
| **Connection joints**  **Bridge body**  **Bridge body** |

If the temperature on the road surface increase (reaching 50oC), which of the following component(s) of the bridge will undergo thermal expansion?

□ The bridge body

□ The connection joints

□ None of the above

**(a) (ii)** In the space below, draw a concept diagram to describe how would the bridge system changes during summer time.

|  |  |
| --- | --- |
| Winter time (10oC) | Summer time (37oC) |
| **Connection joints**  **Bridge body**  **Bridge body** | **Connection joints**  **Bridge body**  **Bridge body** |

**2** In 2017, the outer-part of the Tsing Ma Bridge was re-painted to slow down the rusting on the bridge body.

**(a)** Is rusting a chemical change or a physical change? Explain your answer.

|  |
| --- |
| Answer :  Iron rusting is a chemical change, as the iron rusting process will form new substances (rust). |

**(b)** Explain why painting the bridge could slow down the rusting.

|  |
| --- |
| Answer :  Oxygen and water are required for the formation of rust. The painting on the bridge could keep oxygen and water away from iron for the reaction to occur, which would slow down the rusting. |

**3** A student suggested to use two identical iron nails to perform an experiment to show that sea water would make iron rust faster in a given time interval.

|  |  |
| --- | --- |
| Experimental setup | Control setup |
| **Water temperature : 20oC** | **Water temperature : 25oC** |

List two mistakes in the setup above and describe what changes you would make for the experiment.

|  |  |
| --- | --- |
| Experimental setup | Control setup  **Water** |
| **Sea water**  **Water**  **Oil layer**  **25 oC**  **Water temperature : 20oC**  **Iron nail** | **Water temperature : 25oC**  **Iron nail** |

**3** The table below shows some information about different types of bridges :

|  |  |  |
| --- | --- | --- |
| Types of bridge | Suitable distance between bridge supports (m) | Rough cost ($/m2)  (Estimated according to the area of road surface of the bridge) |
| 一張含有 文字, 螢幕擷取畫面, 設計 的圖片  自動產生的描述Type A | 20 – 50 | 24,000 |
| 一張含有 文字, 螢幕擷取畫面, 設計 的圖片  自動產生的描述Type B | 75 – 100 | 40,000 |
| 一張含有 文字, 螢幕擷取畫面, 設計 的圖片  自動產生的描述Type C | 50 – 552 | 45,000 |
| 一張含有 文字, 螢幕擷取畫面, 設計 的圖片  自動產生的描述Type D | 60 – 1104 | 52,000 |
| 一張含有 文字, 螢幕擷取畫面, 設計 的圖片  自動產生的描述Type E | 100 – 1991 | 80,000 |

For each of the cases below, suggest which types of bridges (A, B, C, D or E) you would recommend. Explain your answer in the space provided.

**i Building Requirement for Bridge X :**

* The distance between two bridge supports is about 1 020 m while the width of the bridge is about 55 m.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Recommendation :  (Teachers may guide students to build an analysis grid (shown in the table below), and discuss with students the best choice of the types of bridge for the engineering project.)   |  |  |  | | --- | --- | --- | | **Types of bridge** | **Whether the suitable distance between bridge supports is fulfilling for the engineering requirement** | **Cost for the construction** | | Type A | × |  | | Type B | × |  | | Type C | × |  | | Type D | √ | (1020 × 55 × 52 000 ≈ $2.92 B) | | Type E | √ | (1020 × 55 × 80 000 ≈ $4.49 B) | |

**ii Building Requirement for Bridge Y :**

* The distance between two bridge supports is about 100 m while the width of the bridge is about 20 m.
* The budget for the construction should be less than $75 000 000.

[Remarks : Teachers could make changes to the requirement for adjusting the difficulty of the task]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Recommendation  (Teachers may guide students to build an analysis grid (shown in the table below), and discuss with students the best choice of the types of bridge for the engineering project.)   |  |  |  | | --- | --- | --- | | **Types of bridge** | **Whether the suitable distance between bridge supports is fulfilling for the engineering requirement** | **Cost for the construction** | | Type A | × |  | | Type B | √ | (100 × 20 × 40 000 ≈ $64 M) | | Type C | √ | (100 × 20 × 45 000 ≈ $72 M) | | Type D | √ | (100 × 20 × 52 000 ≈ $83.2 M) | | Type E | × |  | |

# Engineering Design Activities

# Activity 4 Design and Make a Temporary House for a Puppy

|  |  |
| --- | --- |
| Relevant Topics in  Junior Secondary Science | * Heat transfer |

**Situation**

One day, a lost puppy was found injured on street in a hot summer day.

You and your classmates decided to build a ‘temporary house’ to let the puppy rest inside and stay away from direct sunlight.

**Task**

Students are divided into groups to design, build and test the prototypes using the materials and apparatuses available. The prototypes should satisfy the following conditions :

* Budget cost for making the prototype < $100
* The minimum interior of the prototype : 50 cm (H) x 50 cm (L) x 50 cm (W)
* The difference between room temperature and temperature inside the prototype should be less than 8°C\* for at least 30 minutes under a heat lamp
* The prototype must have an exit

[Remarks : Teachers could make changes to the requirement for adjusting the difficulty of the task]

|  |  |
| --- | --- |
| **List of material** | **Unit price ($)** |
| 0.8 mm metal wire | $0.7 / m |
| 3mm x 3mm wooden stick | $7 / m |
| Cotton String | $0.09 / m |
| Fine Wire Mesh | $25 / m2 |
| A4 paper | $0.5 / 10 sheets |
| 1.5’’ Masking Tape | $0.32 / m |
| Shading Net | $6 / m2 |
| High density Shading Net | $17.5 / m2 |
| Sun reflector film | $38 / m2 |

**Part 1 Developing the prototypes**

Discuss with your groupmates and propose two prototypes of the temporary house. Build the two prototypes using the selected materials and complete the budget report.

Insert the diagrams / photos for the two prototypes built in the space provided.

|  |  |
| --- | --- |
| **Prototype 1** | **Prototype 2** |
|  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Budget Report : Prototype 1** | | | |
| Materials | Unit price ($) | Quantity | Cost ($) |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| **Total** | | |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Budget Report : Prototype 2** | | | |
| Materials | Unit price ($) | Quantity | Cost ($) |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| **Total** | | |  |

**Part 2 Testing the prototypes**

Design an experiment to investigate the performance of Prototype 1 and Prototype 2 The apparatuses to be used in the investigation are listed below :

|  |  |
| --- | --- |
| **List of apparatus** | **Quantity** |
| Heat lamp | 2 |
| Thermometer | 2 |
| Timer | 1 |

**Objective**

* To conduct a fair test for comparing the temperature change inside the prototypes for at least 30 minutes under a heat lamp

**Procedures**

* Draw 4 diagrams in the space below to describe the major steps about how you would conduct the test :

|  |  |
| --- | --- |
| Step 1 | Step 2 |
|  |  |
| Step 3 | Step 4 |
|  |  |

* Conduct the test with the prototypes and record the results in the table below :

Room temperature in area outside the temporary house = \_\_\_\_\_\_oC

|  |  |  |
| --- | --- | --- |
|  | Prototype 1 | Prototype 2 |
| Initial temperature (oC) |  |  |
| Final temperature (oC) |  |  |

**Part 3 Data Analysis**

Describe respectively the strengths and limitations for each of the prototypes and explain whether the prototypes could satisfy the conditions set out in this task.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Advantages | Limitations | Explanation on whether the prototype could satisfy the conditions set out |
| Prototype 1 |  |  |  |
| Prototype 2 |  |  |  |

**Part 4 Evaluation**

Evaluate and select the best design with reference to the criteria.

|  |  |
| --- | --- |
| Criteria | The better prototype is … ( 1 or 2) |
| Budget |  |
| Outlook |  |
| Effectiveness on Insulation |  |

For the prototype selected, suggest what further modification could be done to enhance the performance.

* Prototype \_\_\_\_\_\_ is a better design to accomplish the task.
* We have the following suggestion(s) to further enhance the design :

|  |
| --- |
|  |

# Activity 5 Design and Make a Water Treatment Device

**Water Treatment Works in Hong Kong**

There are now 20 water treatment works in Hong Kong, with a total capacity of 4.68 million cubic metre per day to supply fresh water

Turning raw water into drinking water requires a series of treatment processes. Various chemicals may be added into raw water as pre-treatment, such as alum, powdered activated carbon and lime.

**Task**

Each student group is provided with two plastic containers, some filtering materials and apparatuses to design and make two prototypes of “Water Treatment Model”. The prototypes should satisfy the following conditions :

* Use at least three types of filtering materials
* The time required for obtaining the filtrate should be minimal
* The prototypes must have a filtrate outlet

|  |  |
| --- | --- |
| **Materials** | **Unit price ($)** |
| Fine-grain sand | $40 / kg |
| Large gravel | $20 / kg |
| Small pebbles | $30 / kg |
| Stone | $20 / kg |
| Cotton mesh | $30 / m2 |
| Activated charcoal | $80 / kg |

**Part 1 Developing the prototypes**

Discuss with your groupmates and propose two prototypes of Water Treatment Model. Build the two prototypes using the selected materials and complete the budget report.

Insert the diagrams / photos for the two prototypes built in the space provided.

|  |  |
| --- | --- |
| **Prototype 1** | **Prototype 2** |
|  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Budget Report : Prototype 1** | | | |
| **Materials** | **Unit price ($)** | **Quantity** | **Cost ($)** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| **Total** | | |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Budget Report : Prototype 2** | | | |
| **Materials** | **Unit price ($)** | **Quantity** | **Cost ($)** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| **Total** | | |  |

**Part 2 Testing the prototypes**

Design an experiment to investigate the performance of Prototype 1 and Prototype 2 The apparatuses to be used in the investigation are listed below :

|  |  |
| --- | --- |
| **List of apparatus** | **Quantity (per group)** |
| Raw water (Muddy Water) | 2-3 L |
| Mobile device  (with APP installed for measuring water cloudiness) | 1 |
| Timer | 1 |
| Beaker (250 cm3) | 2 |
| Measuring cylinder | 1 |
| Scissors | 1 |
| Wire mesh | 1 |
| Plastic sheets | A few |

**Objectives**

* To conduct a fair test to compare the water flow rate and the cloudiness of the filtrate produced by the prototypes

**Procedures**

* Draw 4 diagrams in the space below to describe the major steps about how you would conduct the test :

|  |  |
| --- | --- |
| Step 1 | Step 2 |
|  |  |
| Step 3 | Step 4 |
|  |  |

* Conduct a test using the prototypes and record the results in the table below :

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Part I : Measuring water cloudiness** | | |
| Raw water | Filtrate obtained (Prototype 1) | Filtrate obtained (Prototype 2) |
| **Cloudiness\*** |  |  |  |

\*The unit used in the cloudiness measurement : \_\_\_\_\_\_\_\_\_\_\_

|  |  |  |
| --- | --- | --- |
|  | **Part II : Measuring water flow rate** | |
| Prototype 1 | Prototype 2 |
| Volume of the obtained filtrate | \_\_\_\_\_\_\_\_ cm3 | \_\_\_\_\_\_\_\_ cm3 |
| Time required for the filtration | \_\_\_\_\_\_\_\_ s | \_\_\_\_\_\_\_\_ s |
| Water flow rate | \_\_\_\_\_\_\_\_ cm3 / s | \_\_\_\_\_\_\_\_ cm3 / s |

**Part 3 Data Analysis**

Describe respectively the advantages and limitations for each of the prototypes and explain whether the prototypes could satisfy the conditions set out in this task.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Advantages | Limitations | Explanation on whether the prototype could satisfy the conditions set out |
| Prototype 1 |  |  |  |
| Prototype 2 |  |  |  |

**Part 4 Evaluation**

Evaluate and select the best design with reference to the competing criteria.

|  |  |
| --- | --- |
| Criteria | The better prototype is … ( 1 or 2) |
| e.g. Water flow rate |  |
| e.g. Water cloudiness |  |
|  |  |

* Prototype \_\_\_\_\_\_ is a better design to accomplish the task.
* We have the following suggestion(s) to further enhance the design :

|  |
| --- |
|  |

**School Example**

|  |  |
| --- | --- |
| **Design of prototype** |  |
| **Building and testing the prototype** | Y:\Team4\STEM\Final version of STEM package (by CK)\Final Version_R3_20170905\Graphics\Waterplant\waterplant_c_rrrr.JPG |

# Portfolio Template

(Remarks : Teachers can use the portfolio template included in this learning module as a tool to guide students to conduct other suitable ‘Design and Make’ activities.)

**Portfolio Template**

**Science (S1-3) Design and Make Activity**

|  |  |
| --- | --- |
| **Project title** | …………………………………………………………………………………………………… |

|  |  |
| --- | --- |
| **Stage 1** | **Asking Questions and Defining Problems** |
| The engineering problem to be solved : | |
| The constraints of this project : | |
| The criteria to achieve the expected outcome : | |
| The needs of users and the expectations from the stakeholders : | |

|  |  |
| --- | --- |
| **Stage 2** | **Developing Prototypes** |
| Discuss with your groupmates and propose two prototypes for solving the engineering problem.  Build the two prototypes using the selected materials and complete the budget report. | |

|  |  |
| --- | --- |
| **Prototype 1** | **Prototype 2** |
|  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Budget Report : Prototype 1** | | | |
| Materials | Unit price ($) | Quantity | Cost ($) |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| **Total** | | |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Budget Report : Prototype 2** | | | |
| Materials | Unit price ($) | Quantity | Cost ($) |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| **Total** | | |  |

|  |  |
| --- | --- |
| **Stage 3** | **Conducting Investigations** |
| * List the variables of the test. * Describe the procedures of the test. * Present the data in the form of tables or graphs. | |
|  | |

|  |  |
| --- | --- |
| **Stage 4** | **Analysing Data** |
| Describe respectively the advantages and limitations for each of the prototypes and explain whether the prototypes could satisfy the conditions set out in this task. | |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Advantages | Limitations | Explanation on whether the prototype could satisfy the conditions set out |
| Prototype 1 |  |  |  |
| Prototype 2 |  |  |  |

|  |  |
| --- | --- |
| **Stage 5** | **Constructing Explanations and Designing Solutions** |
| Give scientific explanations for the working performance of the prototypes.  Evaluate and select the best design with reference to the criteria, such as desired functions, cost and safety concerns. | |
|  | |

|  |  |
| --- | --- |
| **Stage 6** | **Evaluating and Feedbacks** |
| For the prototype selected, suggest what further modification is required to enhance the performance of the prototype in response to the feedbacks received. | |
|  | |