

## Developing Critical Thinking and Problem Solving Skills through the Design of Experiments

**Curriculum: Science (Secondary 1- 3)**

**Topic: Energy gain and loss**

Traditionally, experimental workbooks usually introduce the concept of energy gain and loss with an experiment on comparing the temperature change of water in containers of different materials over a period of time. The experimental setup and procedures involved are given in detail. Students only need to follow the procedures step by step to perform the experiment and complete a worksheet by answering superficial questions which require little independent thinking. Instead of following the workbook passively, the science teacher could adopt a new approach to develop students' critical thinking through carefully designed activities that are more meaningful and relevant to their daily life, making students take active responsibility for their own learning.

1. What are the initial temperatures of the water in containers A/B?

container A \_\_\_\_\_°C  
container B \_\_\_\_\_°C

2. What are the temperatures of the water in containers A/B after 10 minutes?

container A \_\_\_\_\_°C  
container B \_\_\_\_\_°C

A worksheet of an experiment

***In the end, the teacher may also lead students to compare their work with the textbook - a wise use of the textbook to illustrate how students can explore and learn more!***

- Energy gain and loss is introduced under the topic "Life in space" in the Science (S1-3) curriculum. In discussing the life of astronauts in space, students come to realize the need to maintain body temperature in space. As an introduction to the study of the design of a space suit, the teacher asks students to design and make a thermo-cup. This serves the purpose of illustrating the idea of preventing energy loss.



An aluminum thermo-cup designed by a student

- Students are asked to consider how to choose materials and how the design of their thermo-cups would affect its effectiveness in retaining warmth. They hand in their proposals, describing and explaining their designs in detail.
- Based on students' proposals, the teacher gives written feedback to individual groups, challenging their ideas and helping students to reflect on their designs. As long as safety issues are observed, the teacher encourages students to proceed with their proposals and make their own thermo-cups.
- Different groups of students then present and explain their designs before the class. Students are guided to evaluate the feasibility of each design based on their scientific knowledge.



*Three thermo-cups designed by students*

- After different groups have made their thermo-cups, the teacher leads the whole class to design a fair test to test for the effectiveness of their thermo-cups. The whole class has to decide what measurements to make, what variables to keep unchanged, and how to improve the reliability of the results. Finally, the effectiveness of each thermo-cup is tested according to the criteria the whole class has agreed upon.

**"How should we make the comparison?"**  
*"We should use the same amount of water for each trial."*  
**"... and start with the same temperature too!"**  
*"What should we measure? Would an alcohol thermometer be precise enough for the test?"*  
*"Let's use a data logger for the test and see how the temperature of the water in each thermo-cup changes over time."*

*A snapshot of the class discussion*

- The whole exercise reduces students' reliance on traditional experimental workbooks in science learning. Students go through the process of critically analyzing a problem and proposing the "best solution". The designs are then evaluated scientifically. In the process, students are led to focus on a problem and through the problem-solving activities, their critical thinking, communication, collaboration and study skills are developed.
- A sample activity sheet (in Chinese) is shown in the following pages.

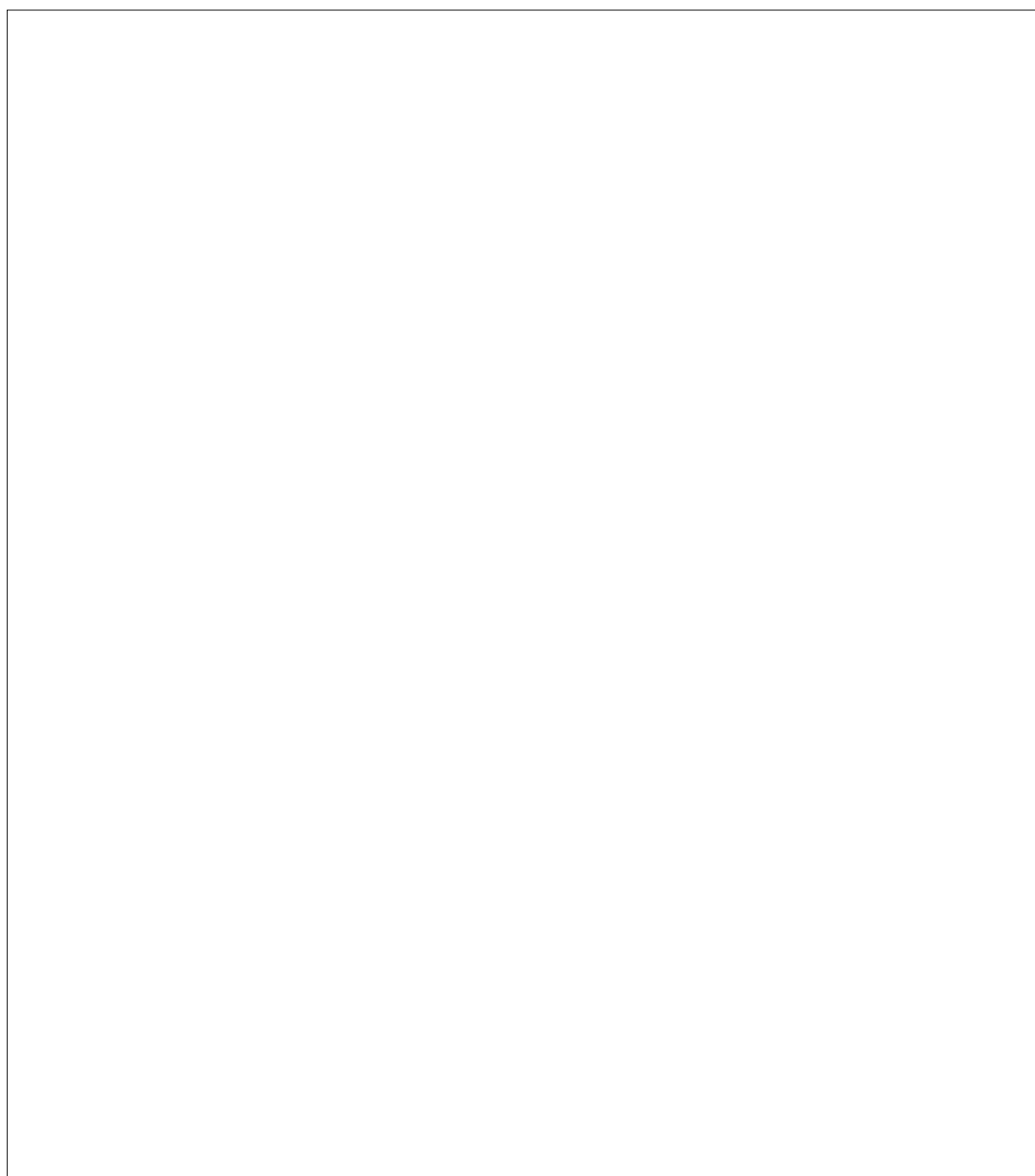
## 單元九 - 太空之旅

### 活動四 製作保溫杯

太空人在太空船外執行任務時，須要保持體溫，所以太空衣一定要使用保溫功能高的物料，配合特別設計製成。你認為那些物料會適合呢？怎樣的設計會有幫助呢？請設計一隻保溫杯，說明你的想法。

#### (甲) 保溫杯設計草圖

請在以下空間，畫出你的保溫杯設計草圖，並標示各部分所使用的物料和設計特色。



## (乙) 保溫杯設計原理

請說明你的設計的保溫原理，並嘗試解釋。

我的保溫杯使用了…，因為…

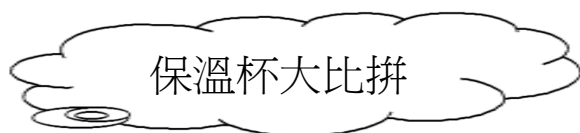
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在這活動中，我們會比較不同保溫杯的效能。請列舉涉及的變數，那些變數須要保持不變？

我認為涉及的變數包括：

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我認為要比拚公平，要保持不變的變數包括：

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你認為比拚應如何進行？

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