Jockey Club STEAM Education Resources Sharing Scheme

Beauty and the Skin

Teachers' Guide

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Jockey Club STEAM Education Resources Sharing Scheme is a 4-year project (2019-2023) funded by The Hong Kong Jockey Club Charities Trust and operated by the School of Science and Technology, Hong Kong Metropolitan University.

Traditionally, knowledge is transferred to students through a teacher-centred approach. Teachers teach students based on a subject-based curriculum that aims at content acquisition. However, little attention is given to how students learn and apply the knowledge to tackle matters in and beyond classrooms. Moreover, the knowledge domains are covered in terms of individual subjects, such as Physics, Biology, Chemistry, and Mathematics. Students learn individual subjects separately without holistic integration. As a result, students may not be sufficiently equipped to solve authentic problems in the real world.

"While Hong Kong students perform well in science, technology and mathematics, they may focus on disciplinary studies and may not evenly participate in hands-on activities in schools. Therefore, it is necessary to strengthen the ability of students to integrate and apply their knowledge and skills across different subject disciplines through solving daily life problems with practical solutions and innovative designs." (Curriculum Development Council, 2015).

Under this Scheme, the operational team will create a set of STEAM modules for secondary schools to strengthen students' ability to integrate and apply their knowledge and skills across different subject disciplines with a special focus on the use of innovative teaching pedagogies for STEAM education, i.e.

Science
Technology
Engineering
Arts
Mathematics

At least 20 modules would be developed to target students of average ability in solving authentic problems in daily life. Each module would provide 4 to 40 contact hours of student activities. In addition, students would do preparation or follow-up activities during non-contact hours. The ratio between contact hours and non-contact hours is approximately 1:1.

This document provides a detailed module plan for learning, teaching and assessment activities. The module will provide an opportunity for students to learn STEAM through hands-on and minds-on activities that integrates knowledge and skills across Science, Technology, Engineering, Arts and Mathematics under real-world contexts.

1 Module Outline

1.1 Module Title: Beauty and the Skin

Nowadays, cosmetics are widely used not only by women but also by men. Although numerous cosmetic products with different functions have been developed, many people do not know how they exactly work but only a few magical words such as “hydration”, “whitening”, “anti-aging”, and “repairing”. In fact, the working principles are closely related to biology and chemistry.

According to the European Union (EU) legislation of regulation, the definition of cosmetic is “*Any substance or mixture intended to be placed in contact with the external part of the human body (epidermis, hair system, nails, lips and external genital organs) ... mainly to cleaning them, changing their appearance, protecting them, keeping them in good conditions or correcting body odours*”. Different cosmetics consist of diverse active ingredients which are intentionally used to serve different purposes mainly for the skin, such as whitening, anti-wrinkle and anti-ageing. Being a rational person, it would be reasonable for us to have some basic understanding of the chemical and biological properties of cosmetic products and how they affect the skin before we buy and apply them on our skin.

In order to understand the working principles of cosmetics by the skin, structure and different parts of the skin, which is the largest organ of the human body, will be covered. In this module, skincare products and the active ingredients, essential oils, will be used as an example and studied extensively. The origin and different chemical and biological properties of the active ingredients will be introduced. By using the scientific knowledge in cosmetic science, students will be able to make their own skincare products at the end of the module.

1.2 Participants Recommended for this Module

☐ Junior Secondary School Students (please specify: S3)
☑ Senior Secondary School Students (please specify: S4-S6)
☐ Others (please specify: _____)

1.3 Module Aims

The module “*Beauty and the Skin*” aims to:

- Introduce how cosmetics affect the conditions of the skin
- Explain the effect of cosmetics by utilising knowledge of chemistry and biology
- Raise students’ awareness of the composition and the active ingredients of cosmetics used in daily life
- Introduce the methods for extraction of essential oils from natural plants
- Provide an opportunity for students to make their own skincare products
- Advance students’ application of subject knowledge and skills learned in the school curriculum of senior secondary (SS) Chemistry and SS Biology

1.4 Module Learning Outcomes

Upon the completion of the module, your students should be able to:

- Identify different structures and parts of the skin
- Describe the functions of the skin
- Understand how cosmetics affect the conditions of the skin
- Explain the effects of cosmetics by applying chemical and biological theories
- List out the functions of different active ingredients and essential oils used in skincare products
- Make their own skincare products

1.5 Learning & Teaching Approach / Practice

Cosmetics have already been used by humans for a long time. The earliest evidence showing the usage of cosmetics (i.e. essential oils) was found in 3,000-2,500 B.C. Even in different ancient countries such as Egypt, India, Rome and China, traces of using cosmetics were discovered. However, the working mechanism of cosmetics remained a mystery in ancient times. Even in today's society, people still seldom truly understand what they have applied to their treasurable skin and the scientific knowledge behind it. In fact, the mystery can be explained by applying the knowledge and theories of chemistry and biology. It is also an excellent example to demonstrate how the knowledge learnt by the students in secondary school can be applied in their daily lives. As STEAM education encourages students to have critical thinking and emphasises on problem-solving skills, this module will adopt a problem-based learning approach to solve real-life problems.

After introducing all the necessary knowledge in Units 1 to 3, students would have a chance to apply their knowledge to make their own skincare products using essential oils in Unit 4.

At the end of the module, students will increase their understanding of STEAM-related subject matter investigated. Transferrable skills such as problem-solving, creativity and critical thinking will also be enhanced.

1.6 Nature of STEAM Activity

Element	Description	Composition
Science	Anatomy of the skin, distillation and soxhlet extraction, chemical structures and functional groups of organic compounds, hydrophobicity and hydrophilicity	✪✪✪✪✪
Technology	Explore the advanced distillation and extraction technologies. IR spectroscopy	✪✪✪
Engineering	Understand the manufacturing process of cosmetic and skincare products	✪✪
Arts	Design the appearance of DIY skincare products	✪✪✪

Mathematics	Calculate and design the composition of DIY skincare products	✪✪

1.7 Mapping of Key Learning Areas (KLAs)

Unit	Science Education	Technology Education	Mathematics Education	Arts Education
1	◆ Anatomy of the human skin ◆ Body defence mechanisms (Skin) (SB4.3) ◆ Regulation of body temperature (Skin) (SB5.2)			
2	◆ Chemistry of carbon compounds (Functional groups) (SC11.3) ◆ Intermolecular forces (SC6.2) ◆ Important organic substances (SC11.5) ◆ Separation and purification methods (SC15.2)	◆ The advanced distillation and extraction processes		
3	◆ Movement of substances across membranes (SB1.3) ◆ Active ingredients and their effects and chemistry of			

	skincare products			
4	◆ Laboratory equipment and basic practical skills (SJ1.4) ◆ Dissolving (SJ2.2)	◆ IR spectroscopy	◆ Using percentages (MJ5.1, 5.2) ◆ Rates, ratios and proportions (MJ6.1, 6.2)	◆ Designing the appearance of skincare products

Remark: Mapping the skill sets in this module with the respective KLAs in the school curriculum that would be covered.

1.8 Module Structure

	Units	Contact Hours	Assessment*
1	Is the skin important to us?	70 mins	Worksheets, lab reports and presentation
2	The origin of cosmetics	100 mins	
3	The magic of cosmetics	120 mins	
4	Making your own skincare products	120 mins	
	Total	**6 hours 50 mins**	

1.9 Thematic Area

- ☑ Environment and Health
- ☐ Food and Biochemistry
- ☐ Digital Transformation
- ☐ S.M.A.R.T.

2 Module Design

Cosmetic science is a multidisciplinary science. It includes chemistry, biology, pharmacology and others. In order to develop an effective and safe cosmetic product, a scientist with basic knowledge of anatomy and physiology, chemistry and formulation technology is needed. For example, structures of the skin, lips and hair, covered in secondary school biology, are essential knowledge for a cosmetic scientist. Understanding the physical and chemical properties of different organic and inorganic compounds is vitally important for scientists to formulate a cosmetic product with appropriate performance. Since some cosmetic products might have therapeutic effects, a piece of basic pharmacological knowledge is also necessary. In conclusion, cosmetic science is an excellent example and tool for STEAM education, emphasising cross-subject and integrative learning.

In order to make skincare products, students are expected to have basic knowledge of anatomy and physiology and organic chemistry. Unit 1 and Unit 2 will familiarise students with the structure of the skin, lips and hair, and organic chemistry, including chemical structures, functional groups, and hydrophobicity. Experimental techniques such as simple distillation and soxhlet extraction will also be introduced in Unit 2.

In Unit 3, the working principles of cosmetic and skincare products will be illustrated. Three important areas will be covered, including skin conditions, how chemicals in cosmetics can affect skin conditions and common cosmetic ingredients (i.e. essential oils) and their effects. After that, students with prior knowledge will be given an opportunity to design and make their own skincare products.

In Unit 4, students are expected to make their own skincare products such as hand cream, lipstick and ointment. They are allowed to choose the essential oils that they like the most to perform the activities and experiments. Finally, they can characterise and test their own products using IR spectroscopy, a powerful instrument in analytical chemistry.

2.1 Unit 1: Is The Skin Important To Us?

Skin is one of the most important organs in the human body. Having a surface area of about 1.5 – 2 m^2 in adults, it is the largest sensory organ in the human body. Consisting of two main layers of different types of cells, the skin is the most important organ for protection against external influences such as UV radiation, pathogens and irritants.

Besides a protective layer, skin is also indispensable for body defence, body water and temperature regulation. The unique structural features and cell types of the skin make it possible to work normally under harsh environmental conditions. In order to understand how cosmetics help to maintain the health of human skin, students are expected to have basic knowledge of the anatomy of the skin.

In this unit, the anatomy and physiology of the human skin will be introduced. This unit would familiarise students with basic knowledge of the human skin, which is necessary for students to understand Unit 2.

2.1.1 Objectives

Upon completion of *Unit 1*, students should be able to:

- Identify different layers of the human skin
- List out the cells and substances found in different layers of the human skin
- Identify the importance and functions of human skin
- Understand the mechanism of the functions of human skin

2.1.2 Pre-requisite (if appropriate)

Nil.

2.1.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction: ◆ Arouse students' interest in relevant real-life issues. ◆ To explain the learning objectives of this unit.	10 mins	◆ PowerPoint slides
(2) Anatomy of the human skin: ◆ To introduce the overall structure of the human skin ◆ To introduce different layers of the human skin ◆ Ask students to identify the different layers	20 mins	◆ PowerPoint slides
(3) Physiology of the human skin: ◆ To introduce the functions of human skin ◆ To explain the working mechanism of the functions ◆ To illustrate how different cell types in the skin play a vital role in maintaining normal skin functions	30 mins	◆ PowerPoint slides
(4) Debriefing: ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	10 mins	◆ PowerPoint slides ◆ Notes
Total	**70 mins**	

2.1.4 Assessment (if appropriate)

- Students' knowledge of the anatomy of the human skin will be assessed through polling and multiple-choice questions
- Students' knowledge of the details of the physiology of the human skin will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.2 Unit 2: The Origin of Cosmetics

Most of the cosmetics are applied directly onto the skin. Products with diverse functions such as moisturisation, cleansing, anti-aging, UV protection and others, are widely used to improve or restore skin conditions. In fact, almost all cosmetics comprise organic compounds in which the chemical structures and the presence of functional groups will largely affect the functions and performance of the products. Therefore, to facilitate the learning of cosmetics and how they work, one should have a basic knowledge of organic chemistry.

Essential oils, one of the most frequently used active ingredients in skincare products, are a mixture of aromatic and volatile compounds extracted from natural plants. Alcohol, triglycerides, fatty acids and terpenes can be easily found in many cosmetic and skincare products. They contain different functional groups such as hydroxyl group, aldehyde, ketone and ester, etc. Due to the difference in functional groups, each type of terpene has a unique combination of useful properties like moisturisation and cleansing.

In this unit, students are expected to comprehend the fundamental concepts of organic chemistry such as structures, functional groups and extraction methods. This unit paves the road for finishing Unit 3 and Unit 4.

2.2.1 Objectives

Upon completion of *Unit 2,* students should be able to:

- Identify different functional groups within organic compounds
- Understand the concept of the polarity of molecules
- Briefly describe different kinds of intermolecular forces
- Briefly understand how different functional groups contribute to different skincare properties
- Describe the underlying principles of distillation and extraction
- Application of distillation and extraction in making cosmetics

2.2.2 Pre-requisite (if appropriate)

Nil.

2.2.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction: ◆ To recap the major ideas of the previous lesson ◆ To assess students' prior knowledge ◆ To explain the learning objectives of this lesson	10 mins	◆ PowerPoint slides
(2) Functional groups within organic compounds: ◆ To introduce the concept of functional groups ◆ To describe the concept of polarity ◆ To introduce different kinds of intermolecular forces ◆ To explain how functional groups contribute to different skincare properties ◆ To illustrate the concept by using real-life examples	40 mins	◆ PowerPoint slides
(3) Important organic substances: ◆ To introduce the definition of detergents ◆ To explain the working mechanism of detergents ◆ To briefly introduce skin cleansing products	20 mins	◆ PowerPoint slides
(4) Distillation and extraction: ◆ To introduce simple distillation and extraction ◆ To explain the working principle of simple distillation and extraction ◆ To demonstrate how simple distillation and extraction can be used to obtain essential oils	20 mins	◆ PowerPoint slides
(5) Debriefing: ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	10 mins	◆ PowerPoint slides ◆ Notes
Total	**100 mins**	

2.2.4 Assessment (if appropriate)

- Students' knowledge of the concept of functional groups and how the groups contribute to different chemical and skincare properties will be assessed through polling and multiple-choice questions
- Students' knowledge of the distillation and extraction will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.3 Unit 3: The Magic of Cosmetics

Since human skin is the largest organ continuously in contact with the environment, the conditions and normal functions such as pH, water content and barrier properties are persistently affected. Because of that, there are numerous cosmetic and skincare products such as cleansers, moisturisers, protective and nourishing creams and lotions available in the market to help maintain the normal conditions of the skin.

In this unit, the working principle of cosmetic and skincare products will be illustrated. Three important areas will be covered, including skin conditions, how chemicals in a cosmetic can affect the skin conditions and common cosmetic ingredients (i.e. essential oils) and their effects. After that, students with prior knowledge will be given an opportunity to design and make their own skincare products.

2.3.1 Objectives

Upon completion of *Unit 3*, students should be able to:

- Describe what are the normal conditions of the skin
- List out the commonly used chemicals in cosmetics for skincare
- Explain how molecules can enter the cells by diffusion
- Explain how the chemicals help to improve or restore the normal conditions of the skin

2.3.2 Pre-requisite (if appropriate)

Nil.

2.3.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction: ◆ To recap knowledge of the previous lessons ◆ To explain the learning objectives of this lesson	10 mins	◆ PowerPoint slides
(2) What is “normal” skin: ◆ To introduce the concept of skin conditions and related functions ◆ To list out the conditions and functions such as pH, water content and barrier properties	10 mins	◆ PowerPoint slides ◆ Online videos
(3) Movement of substances across the membrane: ◆ To explain how molecules can enter the cells by diffusion	10 min	◆ PowerPoint slides ◆

Description	Duration (hr/min)	Resources
(4) Chemicals commonly used in skincare products: ◆ To list out some chemicals commonly used ◆ To explain how the chemicals help to improve or restore the normal skin conditions	45 mins	◆ PowerPoint slides ◆ Online videos
(5) Common skin problems: ◆ To raise the issue of skin problems ◆ To explain the causes of different skin problems ◆ To suggest solutions to tackle some skin problems ◆ To encourage students to suggest some skincare products to tackle skin problems	35 mins	◆ PowerPoint slides ◆
(6) Debriefing: ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	10 mins	◆ PowerPoint slides Notes
Total	**120 mins**	

2.3.4 Assessment (if appropriate)

- Students' knowledge of normal skin conditions and skin problems will be assessed through polling and multiple-choice questions
- Students' knowledge of the working principle of skin care products and how they help to restore the normal conditions of the skin will be assessed through the case study
- Overall students' participation would be reviewed

2.4 Unit 4: Making Your Own Cosmetics and Skincare Products

For the purpose of designing and making cosmetics and skincare products, students should have basic knowledge of organic chemistry and anatomy and physiology of the skin, which has been introduced and covered in Units 1, 2 and 3.

Students with prior knowledge are expected to design and create their own cosmetics. Students will have a chance to mix different ingredients which have various properties or colours and to customise their own skincare products. The products will also be examined by IR spectroscopy. Students will also be encouraged to make a powder or liquid foundation with a colour matching to their own skin tone.

2.4.1 Objectives

Upon completion of *Unit 4*, students should be able to:

- Make basic cosmetics and skincare products
- List out some essential ingredients for making the products
- Describe how the products can be used to soothe a particular skin problem
- Use IR spectroscopy for simple compound characterisation

2.4.2 Pre-requisite (if appropriate)

Nil.

2.4.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction: ◆ To recap knowledge of the previous lessons ◆ To explain the learning objectives of this lesson	10 min	◆ PowerPoint slides
(2) Introduction: ◆ To introduce the aim and procedures of the experiment ◆ To mention the safety issue of the experiment	10 min	◆ PowerPoint slides
(3) Experiment section: ◆ To brief students on what they are going to do in the experiment ◆ To guide students to finish the experiment ◆ Students design the appearance of their own products ◆ Students comment on and appreciate others' works ◆ To characterise the functional groups of simple compounds by using IR spectroscopy	60 min	◆ PowerPoint slides ◆ Activity 1, 2 and 3
(4) Group presentation: ◆ Students as a group will try to describe how the products can be used to soothe some common skin problems	30 min	◆ PowerPoint slides ◆ Notes
(5) Debriefing: ◆ To comment on the skin products made by students, whether the products are correctly made and the appearance ◆ To review the knowledge covered in all units	10 min	◆ PowerPoint slides ◆ Notes
Total	**120 min**	

2.4.4 Assessment (if appropriate)

- Students' scientific knowledge and understanding of the aim and the procedures of making skincare products will be assessed through the laboratory, polling and multiple-choice questions
- Students' knowledge of the working principles of different skincare products will be assessed through polling and multiple-choice questions
- Overall students' participation would be reviewed

3 Resources

3.1 Resources for Unit 1

- Teachers' Guide
- PowerPoint slides
- Notes

3.2 Resources for Unit 2

- Teachers' Guide
- PowerPoint slides
- Activity book
- Notes

3.3 Resources for Unit 3

- Teachers' Guide
- PowerPoint slides
- Online videos
- Activity book
- Notes

3.4 Resources for Unit 4

- Teachers' Guide
- PowerPoint slides
- Activity book
- Notes

4 References

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