DANCER IN WATER - MICROALGAE

Jockey Club STEAM Education Resources Sharing Scheme

Teacher's Guide

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School of Science and Technology
Hong Kong Metropolitan University

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CONTENTS

1. INTRODUCTION

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 is aimed for 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.

2. MODULE OUTLINE

2.1 MODULE TITLE: DANCER IN WATER: MICROALGAE (水舞者: 微藻)

Water covers around 70% of the earth's surface. Aquatic environments, including rivers, lakes, swamps, marshes, mangroves, estuaries, and oceans, are habitats for numerous microalgae. Microalgae consists of greatly diverse forms of microorganisms that can carry out photosynthesis. They contribute to approximately half of the oxygen production on Earth.

With the rapid urbanisation and industrialisation in cities near water bodies, water pollution has become a severe environmental problem. The outbreaks of harmful algal blooms (HABs), caused by the rapid proliferation of microalgae, are the consequences of the worsening water pollution problem. The occurrence of HABs poses threats to public health, seafood safety, water quality, and economic development.

On the other hand, the scientific and industrial communities have been exploiting microalgae for their beneficial uses in human society. For instance, the synthesis of biofuel using microalgae, the treatment of wastewater with microalgae, and the production of cosmetic products and food supplements from microalgae.

It is high time that students learn more about microalgae, the related experimental skills, and their beneficial uses. This module advances students' application of subject knowledge and skills in the secondary school curriculum, including the school curriculum of Science S1 Unit 2: Water, Senior Secondary (SS) Biology: Applied Ecology, and SS Mathematics: Exponential and logarithmic functions,

There are 3 units in the module. Unit 1 "Getting to know microalgae" introduces the basic knowledge of microalgae. Unit 2 "Cultivation microalgae" provides knowledge and hands-on experience to students to acquire the laboratory techniques related to the isolation, cultivation, and enumeration of microalgae. Unit 3 "The dancing microalgae in the spotlights" requires students to design and conduct experiments to explore some biological concepts concerning microalgae.

Through this module, students can enhance their knowledge of microalgae, get updated on the modern applications of microalgae to human society, and perfect their laboratory skills in general microbiology.

2.2 PARTICIPANTS RECOMMENDED FOR THIS MODULE

- ☐ Junior Secondary School Students (please specify:_____)
- ☑ Senior Secondary School Students (please specify:_F4-F6_____)
- ☐ Others (please specify: students who are interested in exploring engineering as future study/career)

2.3 MODULE AIMS

The module Dancer in Water: Microalgae **(水舞者: 微藻)** aims to:

- provide students with authentic experience in microalgal cell isolation in the laboratory
- enrich students' pipetting skills through hands-on laboratory experiments or group activities
- let students recognise the Mathematics & Science concepts behind microalgal-related experiments or projects
- advance students' application of subject knowledge and skills learned in the school curriculum of Science *(Unit 2: Water)*, Biology *(Applied Ecology)*, and Mathematics *(Exponential and logarithmic functions)*

2.4 MODULE LEARNING OUTCOMES

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

- Isolate microalgae in environmental water samples
- Select and use appropriate skills in cultivating a single strain of microalgae
- Conduct microalgal counting by using a microscope
- Quantify the population growth rate of microalgae
- Design and conduct experiment to demonstrate the phototaxis of microalgae

2.5 LEARNING & TEACHING APPROACH/PRACTICE

This module will use a problem-based learning approach with hands-on experience and problem-solving activities to achieve the learning outcomes. One lecture on related topics of microalgae will be delivered to students. Following the lecture, a workshop will introduce students to various technological tools in the isolation, cultivation, and counting of microalgae. Students will be given guidance and opportunities to practise the techniques. In particular, they will learn to conduct a scientific investigation study on the phototaxis of microalgae.

In general, an investigative study involves 5 stages:

(1) Identifying relevant information and defining questions for study;
(2) Planning an investigation that involves choosing equipment and resources;
(3) Conducting the investigation;
(4) Organising and analysing information; drawing conclusions based on evidence;
(5) Presenting the findings.

At the end of the module, students will improve their understanding of microalgae and related topics, develop the ability to conduct investigations and improve their skills in communication, creativity, collaboration, critical thinking, problem-solving and IT.

2.6 NATURE OF STEAM ACTIVITY

Element	Description	Composition
Science	Integrate environmental science related topics in biology and chemistry	✪✪✪✪
Technology	Understand the microalgal fatty acid production process	✪
Engineering	Understand the engineering concept of producing microalgal biofuel	✪
Arts	Present the beauty of various microalgal species under a microscope	✪✪
Mathematics	Make use of statistical data to estimate the growth condition of microalgae	✪✪

2.7 MAPPING OF KEY LEARNING AREAS (KLAS)

Unit	Science Education	Technology Education	Mathematics Education	Arts Education	Others *(please specify)*
Unit 1	SJ2.4 SJ2.5 SB3.6 Sewage treatment (SB6.2) Eutrophication and algal boom (SB6.4) Growth of microorganisms & Aseptic techniques (SB7.1) Sewage treatment (SB7.2)				
Unit 2	Laboratory equipment and basic practical skills (SJ1.4) Growth of microorganisms & Aseptic techniques (SB7.1)	Choice, use and care of tools equipment and chemicals (TK5.2) Appropriate choice and use of tools, equipment and machines for the realisation of design Solution (TK 5.6)	Solve exponential equations and logarithmic equations (MS3.5)		

Unit	Science Education	Technology Education	Mathematics Education	Arts Education	Others *(please specify)*
Unit 3	Laboratory equipment and basic practical skills (SJ1.4)	Choice, use and care of tools equipment and chemicals (TK5.2) Appropriate choice and use of tools, equipment and machines for the realisation of design Solution (TK 5.6)			

2.8 MODULE STRUCTURE

	Units	Contact Hours
1	Getting to know microalgae	1
2	Cultivation of microalgae	2
3	The dancing microalgae in the spotlights	3
	Total	**6 hrs**

*Remark: A total of **ONE** non-contact hour of the module is recommended.*

3. MODULE DESIGN

This module consists of three units, accompanied by a teacher's guide, a student workbook, PowerPoint slides for teaching, and an identification key for microalgae. This module is designed to progressively increase the engagement and hands-on practice of students so as to develop a deep understanding of the academic concepts, familiarise them with the technological tools, and to master the skills in an investigative study.

Unit 1 will help arouse students' interest by introducing the background information about microalgae and how microalgae are related to our daily lives. Students will get to know about the basic taxonomy, growth phases, beneficial applications and the environmental problems associated with microalgae.

Followed by Unit 2, students will deepen their knowledge in microalgae by learning different technological tools for the isolation, cultivation, and enumeration of microalgae. More importantly, they will have the opportunity to apply these tools to prepare their own microalgae cultures and to estimate the growth condition of microalgae.

Unit 3 will require students to apply all the acquired knowledge and skills to design and conduct an investigative study on the phototaxis of microalgae. They will have to choose the appropriate equipment and materials to set up and conduct their own experiment. They will also need to take measurements and record the results, analyse the data, and present the findings. Each group will have to conduct a 10-minute oral presentation to deliver their findings.

3.1 UNIT 1: GETTING TO KNOW MICROALGAE

Microalgae are photosynthetic microorganisms that exist in almost all types of aquatic habitats on Earth. They contribute substantially to global primary production and generate the oxygen that is essential to most living things. They are also important food sources for organisms in the food chain.

In Unit 1, through lecturing and active engagement, students will be introduced to the basic biology and classification of microalgae, the wide range of uses of microalgae, and the relationship between microalgae and water quality, seafood safety, global warming and renewable energy.

3.1.1 OBJECTIVE

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

- Understand the fundamental knowledge of microalgae
- Recognise the wide range of beneficial applications of microalgae
- Outline the various relationships between microalgae and water quality, seafood safety, global warming and renewable energy.

3.1.2 PRE-REQUISITE (IF APPROPRIATE)

N/A

3.1.3 DESCRIPTION OF ACTIVITY

Description	Duration (hr/min)	Resources
(1) Introduction ● The teacher assesses students' prior knowledge ● The teacher explains the learning objectives of this unit	5 min	
(2) Basic knowledge of microalgae ● The teacher introduces the biological classification of microalgae ● The teacher explains the wide range of uses of microalgae ● The teacher addresses the relationship between microalgae and water quality and seafood safety. ● The teacher illustrates the relationship between microalgae and global warming and renewable energy.	50 min	● PPT (Unit 1) ● Student Workbook ● Teacher's Guide
(3) Debriefing • The teacher reviews the knowledge covered in this session • The teacher briefly introduces the next Unit	5 min	● PPT (Unit 1)
Total	**1 hr**	

3.1.4 ASSESSMENT (IF APPROPRIATE)

- Students' acquirement of knowledge covered in this module would be assessed through the student worksheet with MCQs and short questions.

3.2 UNIT 2: CULTIVATION OF MICROALGAE

Practical laboratory skills in microalgae are as important as in-depth broad-width knowledge in microalgae. To obtain cultures of a single species or strain of microalgae, there are different cell isolation methods available. The cultivation skills of microalgae are essential in maintaining microalgae cultures that could be used in experiments to explore their biology and beneficial applications. The cell counting and application of statistical data provide an effective way to estimate the growth condition of microalgae cultures.

In Unit 2, students will work as a group and be provided with hands-on experience and guidance in using laboratory techniques to isolate microalgae from environmental water

samples, preparing microalgae cultures with aseptic techniques, counting microalgae cultures with microscopes, and estimating the growth condition of microalgae.

3.2.1 OBJECTIVE

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

- Isolate microalgae in environmental water samples
- Select and use appropriate skills in cultivating a single strain of microalgae
- Conduct microalgal counting with a microscope

3.2.2 PRE-REQUISITE (IF APPROPRIATE)

N/A

3.2.3 DESCRIPTION OF ACTIVITY

Description	Duration (hr/min)	Resources
(1) Introduction • The teacher assesses students' prior knowledge • The teacher briefs the learning objectives of this Unit	5 min	
(2) Basic pipetting techniques • The teacher shows the proper techniques in using the autopipettes • Students practise and perfect their pipetting techniques	10 min	● PPT (Unit 2) ● Student Workbook ● Teacher's Guide
(3) Isolation of microalgal cells • The teacher introduces the various techniques used in the isolation of microalgal cells from environmental samples. Sterilisation methods are also introduced. • Students try some of the introduced techniques themselves	40 min	● PPT (Unit 2) ● Student Workbook ● Teacher's Guide
(4) Cultivation of microalgae • The teacher introduces and demonstrates the equipment and materials required, the preparation of the medium, and methods of sub-culturing • Students prepare their own medium and sub-culture their own microalgae cultures	20 min	● PPT (Unit 2) ● Student Workbook ● Teacher's Guide
(5) Counting microalgal cells	40 min	● PPT (Unit 2) ● Student Workbook ● Teacher's Guide

• The teacher illustrates the techniques in using microscopes to observe and count microalgal cells. • Students count the microalgae samples provided and determine the cell densities of the cultures • Students use statistical data to estimate the growth condition of microalgae in the samples		
(6) Debriefing • The teacher reviews the knowledge covered in this session • The teacher briefly introduces the next Unit	5 min	● PPT (Unit 2)
Total	**2 hr**	

3.2.4 ASSESSMENT (IF APPROPRIATE)

- Students' ability to properly perform the laboratory techniques
- The estimated growth condition of microalgae cultures by students will be assessed
- The overall participation will be reviewed

3.3 UNIT 3: THE DANCING MICROALGAE IN THE SPOTLIGHTS

While microalgae are plant-like microscopic organisms, they are not completely a plant since microalgal cells can move or swim in the water, particularly for some flagellated species. Upon receiving stimulation, certain microalgal species can move or swim from one position to another. The Movement of microalgae allows them to reach places that provide favourable growth conditions or allow them to avoid predation by consumers. One common feature of microalgae upon stimulation is phototaxis. Phototaxis of microalgae enables them to move directionally, either towards or away from, in response to a light source.

In Unit 3, students will work as a group to conduct an investigative study on the topic of phototaxis of microalgae. Following the 5 stages of an investigative study, students will first identify the relevant information of a study question provided by the teacher. Students will then plan the investigation by choosing the right equipment and resources, and figuring out the experimental procedures. After carrying out the investigation themselves, students will have to analyse and interpret the data and draw conclusions based on evidence. Lastly, students will have to give a 10-minute oral presentation of their findings.

3.3.1 OBJECTIVE

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

- Identify the relevant information of a study topic

- Design and plan the steps in carrying out an investigative study
- Conduct the investigative study with the appropriate equipment and resources
- Analyse and interpret collected data
- Communicate the findings of the investigative study to the audience
- Explain phototaxis in microalgae

3.3.2 PRE-REQUISITE (IF APPROPRIATE)

N/A

3.3.3 DESCRIPTION OF ACTIVITY

Description	Duration (hr/min)	Resources
(1) Introduction • The teacher assesses students' prior knowledge • The teacher briefs the learning objectives of this Unit	5 min	
(2) Introduction to an investigative study • The teacher explains the stages of conducting an investigative study	15 min	● PPT (Unit 3) ● Student Workbook ● Teacher's Guide
(3) Introduction to phototaxis of microalgae • The teacher introduces the phototaxis of microalgae • The teacher explains the study topic	10 min	● PPT (Unit 3) ● Student Workbook ● Teacher's Guide
(4) An investigative study on the phototaxis of microalgae • Students design and plan their investigative study and choose the appropriate equipment and resources • Students carry out the investigative study and take measurements and record the results of the study • Students analyse and organise their data and draw conclusions • Students present their findings in a 10-minute oral presentation	2 hr 20 min	● PPT (Unit 3) ● Student Workbook ● Teacher's Guide
(5) Debriefing • The teacher reviews the knowledge covered in all Units • Students reflect and conclude their work	10 min	● PPT (Unit 3)
Total	**3 hrs**	

3.1.4 ASSESSMENT (IF APPROPRIATE)

- Students' ability to design an investigative study and choose the appropriate equipment and resources.
- Success in organising, analysing, and interpreting data will be noticed.
- Overall students' participation will be reviewed.

4. RESOURCES

4.1 RESOURCES FOR UNIT 1 GETTING TO KNOW MICROALGAE

- PPT (Unit 1)
- Teacher's Guide
- Student Workbook

4.2 RESOURCES FOR UNIT 2 CULTIVATION OF MICROALGAE

- PPT (Unit 2)
- Teacher's Guide
- Student Workbook

4.3 RESOURCES FOR UNIT 3 THE DANCING MICROALGAE IN THE SPOTLIGHTS

- PPT (Unit 3)
- Teacher's Guide
- Student Workbook

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6. PROJECT TEAM

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