Jockey Club STEAM Education Resources Sharing Scheme

Eternal War - Pathogens

Teachers' Guide

First Edition January 2022

School of Science and Technology
Hong Kong Metropolitan University

Ho Man Tin, Kowloon, Hong Kong

Table of Contents

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.

1 Module Outline

1.1 Module Title: Eternal War - Pathogens

Nowadays, the importance of wearing masks and using hand gel has been shown due to the pandemic, and people started to pay more attention to their personal hygiene. Do you remember the situation in early 2020? Masks and hand gel were completely sold out in many stores and supermarkets, while many people still did not get one. Although we know the importance of masks and hand gel and use them every day, we seldom know how they work. Perhaps, you may wonder whether the hand gel effectively keeps your hands clean and eliminates bacteria and viruses. To answer this question, it is better to know more about humans' enemies – pathogens.

Pathogens are disease-causing materials, whether living or non-living. Both bacteria and viruses are classified as pathogens. To cause disease in humans, bacteria and viruses must first enter the human body through various means. As a result, blocking the entry paths to the human body by using disinfectant hand gel and wearing masks becomes the primary prevention strategy.

In this module, the basic structures of pathogens such as bacteria and viruses will be introduced. The concepts of health and sickness or disease and the causes of infectious diseases will be illustrated. The working mechanisms of mask and disinfectant hand gel will also be explained. Activities such as making disinfectant hand gel, spread plate technique and coding using Micro:bit will be provided for students to apply the knowledge they learnt.

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 "*Eternal War - Pathogens*" aims to:

- Introduce the basic knowledge of microbiology, mainly related to bacteria and viruses
- Raise students' awareness of the scientific knowledge and working principles of disinfectant hand gel and mask
- Provide a chance for students to make use of technology to facilitate their biological experiments
- Advance students' application of subject knowledge and skills learned in the school curriculum of SS Chemistry and Biology

1.4 Module Learning Outcomes

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

- Identify the basic structures of pathogens such as bacteria and viruses
- Understand the concepts of health and disease and the basic infection mechanism of pathogens
- Explain the working principles of alcohol-based hand gel and mask
- List out the materials used in making disinfectant hand gel
- Perform spread plate experiment and ATP-bacteria test
- Design a colony-counting device by using simple coding and Micro:bit

1.5 Learning & Teaching Approach / Practice

Since 2020, disinfectant hand gel and masks have been the hottest items around the world, especially in Hong Kong. Both are considered effective weapons for fighting against pandemics caused by viruses or bacteria. Not only are they easily affordable, but they are also effective in preventing viral and bacterial infections. In fact, the working principles of these two are also simple enough for Senior Secondary (SS) students to understand.

In this module, the basic structures of pathogens such as bacteria and viruses will be introduced. The concepts of health and sickness or disease and the causes of infectious diseases will be illustrated with examples in Unit 1. After acquiring the basic knowledge of microbiology, the working principles of how disinfectant hand gel and mask can be used to prevent infection will be discussed in Unit 2. Furthermore, the knowledge will be consolidated by several hands-on activities such as making disinfectant hand gel, spread plate technique and ATP-bacteria test in Unit 3. At the end of the module, students would have a chance to make and design a colony-counting device using simple coding and Micro:bit. This module will adopt both problem-based learning and experimental approaches to explain different scientific knowledge.

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

1.6 Nature of STEAM Activity

Element	Description	Composition
Science	Microbiology, harmful effects of microorganisms, disease, dissolving, polarity of bond and molecule, intermolecular forces	✪✪✪✪✪
Technology	Spread plate technique, ATP-bacteria testing	✪✪✪✪
Engineering	Making a colony-counting device by using Micro:bit	✪✪✪✪
Arts	Design of a colony-counting device	✪✪✪
Mathematics	Using percentages, rates, ratios and proportions	✪✪

1.7 Mapping of Key Learning Areas (KLAs)

Unit	Science Education	Technology Education	Mathematics Education	Arts Education
1	◆ Cellular organisation (SB1.2) ◆ Meaning of health (SB4.1) ◆ Diseases (SB4.2) ◆ Microbiology (SB7.1) Harmful effects of microorganisms (SB7.4)			
2	◆ Dissolving (SJ6.3) ◆ Diseases (SB4.2) ◆ Microbiology (SB7.1) ◆ Harmful effects of microorganisms (SB7.4) ◆ Polarity of bond and molecule (SC6.1) ◆ Intermolecular forces (SC6.2) ◆ Introduction to selected homologous series (SC11.1)			
3	◆ Microbiology (SB7.1)	◆ ATP-bacteria test	◆ Using percentages (MJ5.1, 5.2) ◆ Rates, ratios and proportions (MJ6.1, 6.2)	
4	◆ Microbiology (SB7.1)	◆ Concepts of a system (TK8.1) ◆ Programming concepts (TK2.2) ◆ Application of systems (TK9.2)		◆ Design of the colony-counting device

		◆ System integration (TE6.3)		

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	Identify your enemies	120 mins	Worksheets, lab reports and presentation
2	They may cry	130 mins	
3	Now you see them	140 mins	
4	micro:bit - DIY colony counter	150 mins	
	Total	**9 hours**	

*Remark: A total of **1.5** non-contact hours of the module is recommended.*

1.9 Thematic Area

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

2 Module Design

Since many diseases are caused by bacterial or viral infections, it is beneficial for students to learn more about them. Through real-life examples such as disinfectant hand gel and masks, the knowledge of microbiology can be delivered effectively and vividly. Not only the spread plate technique, which is the classical experiment of microbiology, but also the up-to-date bacterial detection method will be involved in this module. Nevertheless, this module will encourage students to make their own colony-counting device by using simple coding and micro:bit to facilitate their microbiology experiment.

In Unit 1, it will familiarise students with the basic structures of bacteria and viruses. The definition of health and disease and the causes of infectious disease will also be illustrated with examples.

Chemical knowledge and working principles of how disinfectant hand gel and masks are used to protect against bacterial and viral infections will be explained in Unit 2. This unit will mainly focus on the chemical compositions of alcohol-based hand gel and how the chemicals can be used to eliminate bacteria and viruses. In the end, students will try to make their own disinfectant hand gel by using alcohol.

In Unit 3, students are encouraged to check the level of bacteria in the environment by using the spread plate method. Several experimental techniques such as swab sampling, aseptic technique and serial dilution will be introduced. Apart from using the classical method, this unit will allow students to use an up-to-date bacteria detection test called the ATP-bacteria test. This test can provide quick results and is easy to use and convenient. Finally, students can rank the "cleanliness" of different locations tested and compare the results obtained between the spread plate method and the ATP-bacteria test.

In Unit 4, students will make a colony-counting device to facilitate the spread plate experiment mentioned in Unit 3. The students will be required to develop a simple but accurate counting system by using Makecode and Micro:bit. The mechanical part of the counting device can be designed by them.

2.1 Unit 1: Identify Your Enemies

Before diving into the working principles of disinfectant hand gel and mask, we need to acquire some basic knowledge of our enemies, bacteria and viruses. Although both bacteria and viruses are pathogens and can cause diseases in humans, their structures are quite different from each other. Bacteria, just like fungi and protozoa, are living organisms while viruses are not. In this unit, both the structural similarities and differences between bacteria and viruses will be introduced and compared. In addition, the concept of health and its infection mechanisms of them will also be explained and illustrated with examples.

This unit would familiarise students with the fundamental knowledge of microbiology which are necessary for students to understand Unit 2.

2.1.1 Objectives

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

- Identify the basic structures of bacteria and viruses
- Understand the definition of health and diseases
- List out some causes of infectious diseases
- Explain how infectious diseases are transmitted
- List out some treatments for infectious diseases

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) The structures of bacteria and viruses ◆ To introduce structural features of bacteria and viruses ◆ To compare the structures between bacteria and viruses	15 mins	◆ PowerPoint slides
(3) The definitions of health and diseases ◆ The definition of health ◆ The definition of diseases	10 mins	◆ PowerPoint slides
(4) The causes of infectious diseases: ◆ To explain how viruses cause diseases in the human body ◆ To explain how bacteria cause diseases in the human body	40 mins	◆ PowerPoint slides
(5) How infectious diseases are transmitted and treated ◆ To introduce different transmission pathways ◆ To list out some treatments used to treat the diseases	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**	

2.1.4 Assessment (if appropriate)

- Students' knowledge of the structure of bacteria and viruses will be assessed through polling and multiple-choice questions
- Students' knowledge of the causes, transmission and treatments of infectious diseases will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.2 Unit 2: They May Cry

Since 2020, disinfectant hand gel and masks have been daily necessities around the world, especially in Hong Kong. Not only are they easily affordable, but they are also effective in the prevention of viral and bacterial infections. However, the working principles do not seem to be so obvious to most people. In fact, once students get the ideas introduced in Unit 1, the working principles are not difficult for them to understand.

In Unit 2, chemical knowledge and working principles of disinfectant hand gel and masks used to protect against bacterial and viral infections will be explained. This unit will mainly focus on the chemical compositions of alcohol-based hand gel and how the chemicals can be used to eliminate bacteria and viruses. In the end, students will try to make their own disinfectant hand gel by using alcohol. Students are expected to familiarise themselves with the working principles of hand gel and mask after studying this unit which would pave the road for understanding Unit 3 and Unit 4.

2.2.1 Objectives

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

- Understand the working principles of disinfectant hand gel and mask
- List out the materials used for making disinfectant hand gel and mask
- Explain the functions of the materials used for making hand gel and mask
- Make an alcohol-based disinfectant hand gel

2.2.2 Pre-requisite (if appropriate)

Nil.

2.2.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction: ◆ To recap major ideas from the previous lesson ◆ To assess students' prior knowledge ◆ To explain the learning objectives of this lesson	10 mins	◆ PowerPoint slides

Description	Duration (hr/min)	Resources
(2) The working principle of hand gel: ◆ To introduce the definition of disinfectant ◆ To explain the working principle ◆ To list out the chemical compositions ◆ To explain the functions of the chemicals	60 mins	◆ PowerPoint slides ◆ Activity 1
(3) The working principle of mask: ◆ To introduce the purpose of using a mask ◆ To explain the working principle ◆ To list out the materials used in making a mask ◆ To explain the functions of the materials used	50 mins	◆ PowerPoint slides ◆ Masks
(4) Debriefing: ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	10 mins	◆ PowerPoint slides ◆ Notes
Total	**130 mins**	

2.2.4 Assessment (if appropriate)

- Student's knowledge and understanding of the working principles, materials used, and scientific explanations of disinfectant hand gel and masks will be assessed through polling and multiple-choice questions
- Overall students' participation would be reviewed

2.3 Unit 3: Now You See Them

After studying Units 1 and 2, students are expected to know the working principles of disinfectant hand gel and mask. However, are they, for example, the DIY hand gel, really working well as expected? Since pathogens like bacteria and viruses are not observable by the naked eyes, scientists have invented different tools to make them visible. In this unit, different methods and technologies used to detect bacteria will be introduced. Not only the most classical experiment, the spread plate method, but also some advanced technologies will be demonstrated. After the experiments, students will know the level of bacteria in a selected location or sample.

In this unit, the spread plate method, including swab sampling, aseptic technique, serial dilution, spread plate technique, colony counting and calculation, will be demonstrated. Students are expected to identify a selected location or sample and perform the test in groups or individuals. A new technology called the ATP-bacteria test, which is easy to use and convenient, will also be introduced to students, and they might try to use it and compare the results obtained.

2.3.1 Objectives

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

- Understand the scientific principles of the spread plate method and ATP-bacteria test
- Perform the spread plate experiments and the ATP-bacteria test
- Calculate the level of bacteria in a selected location or sample
- Compare the “cleanliness” between different locations or samples

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) Safety instruction ◆ To mention the safety issues of using different chemical reagents	10 mins	◆ PowerPoint slides ◆ Activity 2
(3) Swab sampling, aseptic technique and serial dilution: ◆ To introduce the materials used ◆ To demonstrate the techniques ◆ To allow students to select a location or sample for sampling	35 mins	◆ PowerPoint slides ◆ Activity 2
(4) Spread plate technique: ◆ To introduce the materials used ◆ To demonstrate how to do the spread plate technique properly ◆ To incubate the plates for 24 -48 hours ◆ To check the results after the incubation completed	30 mins	◆ PowerPoint slides ◆ Activity 2
(5) ATP-bacteria test: ◆ To explain the working principle ◆ To demonstrate the test ◆ To allow students to select a location or sample for testing	30 mins	◆ PowerPoint slides ◆ Activity 3
(6) Debriefing: ◆ To compare the results obtained from the two different tests ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	25 mins	◆ PowerPoint slides ◆ Notes
Total	**140 mins**	

2.3.4 Assessment (if appropriate)

- Student's knowledge and understanding of the ATP-bacteria test will be assessed through polling and multiple-choice questions
- Student's knowledge and understanding of the spread plate method and laboratory skills such as sampling, aseptic technique and serial dilution will be assessed through the lab report
- Overall students' participation would be reviewed

2.4 Unit 4: Micro:bit – DIY Colony Counter

After the spread plate experiment, students might find that counting the colonies on the plate after incubation could be error-prone. In fact, a device called colony counter or colonometer can be used to facilitate the counting. Since the working mechanism of the colonometer is straightforward, students can try to design and make it by themselves.

In Unit 4, students will design a colony-counting device to facilitate the spread plate experiment mentioned in Unit 3. Students will be required to develop a simple but accurate counting system by using Makecode and Micro:bit. The mechanical part of the counting device can be freely designed by them.

2.4.1 Objectives

Upon completion of *Unit 4*, students should be able to:
- Understand simple computer programming language
- Program Micro:bit with blocks for some simple functions
- Improve their programs by trial and error
- Design a program for the colony counting device
- Construct the mechanical part of the colony counting device

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) Colony counter: ◆ To introduce the functions of colony counter	10 min	◆ PowerPoint slides ◆ Activity 4

Description	Duration (hr/min)	Resources
(3) Simple programming: ◆ To teach the students how to use Makecode ◆ To write the counting program with the students ◆ To explain the design of the program ◆ To test the program by using Micro:bit	60 min	◆ PowerPoint slides ◆ Makecode ◆ Micro:bit
(4) Design the mechanical part of the device: ◆ To construct the mechanical part with the students ◆ To encourage the students to have their own designs	60 min	◆ PowerPoint slides ◆ Notes
(5) Debriefing: ◆ To review the knowledge covered in all units	10 min	◆ PowerPoint slides ◆ Notes
Total	**150 min**	

2.4.4 Assessment (if appropriate)

- Student's scientific knowledge and understanding of simple programming will be assessed through their performance
- 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

Curriculum Development Council & Hong Kong Examinations and Assessment Authority (2007). *Technology Education Key Learning Area: Technology and Living -Curriculum and Assessment Guide (Secondary 4 - 6).* Hong Kong: Government Logistics Department. Retrieved November, 2015, from https://www.edb.gov.hk/attachment/en/curriculum-development/kla/technology-edu/curriculum-doc/TL_CAGuide_e_2015

Curriculum Development Council & Hong Kong Examinations and Assessment Authority (2007). *Science Education Key Learning Area: Biology - Curriculum and Assessment Guide (Secondary 4 - 6).* Hong Kong: Government Logistics Department. Retrieved November, 2015, from https://www.edb.gov.hk/attachment/en/curriculum-development/kla/science-edu/Bio_C_and_A_Guide_updated_e_20151126.pdf

Curriculum Development Council & Hong Kong Examinations and Assessment Authority (2007). *Science Education Key Learning Area: Chemistry - Curriculum and Assessment Guide (Secondary 4 - 6).* Hong Kong: Government Logistics Department. Retrieved June, 2018, from https://www.edb.gov.hk/attachment/en/curriculum-development/kla/science-edu/Chem_C_and_A_Guide_updated_Eng_22082018.pdf

Curriculum Development Council & Hong Kong Examinations and Assessment Authority (2007). *Mathematics Education Key Learning Area: Mathematics - Curriculum and Assessment Guide (Secondary 4-6).* Hong Kong: Government Logistics Department. Retrieved December, 2017, from pdfhttps://www.edb.gov.hk/attachment/en/curriculum-development/kla/ma/curr/CA_2017_e.pdf

Curriculum Development Council & Hong Kong Examinations and Assessment Authority (2007). *Science Education Key Learning Area: Combined Science - Curriculum and Assessment Guide (Secondary 4 - 6).* Hong Kong: Government Logistics Department. Retrieved June, 2018, from https://www.edb.gov.hk/attachment/en/curriculum-development/kla/science-edu/CS_C_and_A_Guide_updated_Eng_22082018.pdf

UltraSnapTM Surface ATP test instruction for use with HygienaTM ATP Monitoring Systems

5 Project Team

Dr. LI Tin-Lok Matthew
School of Science and Technology, Hong Kong Metropolitan University