Jockey Club STEAM Education Resources Sharing Scheme

Micro:bit Inventor

Teachers' Guides

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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, The Open University of Hong Kong.

Traditionally, knowledge is transferred to students through a teacher-centred approach. Teachers teach students based on a subject-based curriculum that 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: Micro:bit Inventor

Learning about innovation and coding is crucial in modern-day education. In this module, we are introducing STEAM Education with micro:bit and sensor kit sets, which combines Science, Technology, Engineering, Art, and Mathematics in one integrated approach to learning.

The micro:bit is a small microcontroller developed by BBC. It is specifically designed for young learners to experiment with coding and invention. The micro:bit is about the same size as a credit card and has buttons, lights, and internal sensors. It can be programmed to do many things, such as playing games, tracking steps, sending messages, and more.

To use the micro:bit, you need to write simple code or use block language to give instructions to the micro:bit board. The micro:bit is an excellent way to start learning about science and technology. It's a fun and educational tool that can help learners of all ages explore the world of technology and coding.

1.2 Participants Recommended for this Module

☑ Junior Secondary School Students (please specify: S1-S3)
☑ Senior Secondary School Students (please specify: S4-S6)
☐ Others (please specify: _____)

1.3 Module Aims

The module “Micro:bit Inventor” aims to:

- Provide a comprehensive STEAM program for students to learn coding using the Micro:bit board and sensor kits.
- Teach students about Micro:bit hardware and block coding under the MakeCode coding platform, as well as the role of sensors in the Internet of Things (IoT).
- Enhance students' computational thinking and problem-solving skills through a number of hands-on projects.
- Promote an interactive learning environment for students to apply STEM knowledge to solve real world problems.

1.4 Module Learning Outcomes

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

- Utilize Micro:bit hardware and block coding under the MakeCode coding platform.
- Describe the role of sensors in the Internet of Things (IoT) and solve real-life problems using micro:bit's coding capabilities.
- Apply practical experience in physical computing, IoT principles, and hands-on projects such as building a traffic light system and a plant monitoring device in urban farming.
- Utilize sound and touch sensors, frequency, sound production, and analog writing, which will enable them to create musical projects using micro:bit.
- Use micro:bit to solve real-world problems and create practical applications.
- Strengthen their problem-solving skills and have a foundation for future studies in computer science or engineering fields.
- Apply their STEAM skills and knowledge to real-life scenarios.

1.5 Learning & Teaching Approach / Practice

There are 6 units in this module.
Unit 1 – Introduction to micro:bit;
Unit 2 – Micro:bit Sensors;
Unit 3 – Micro:bit Sensors (for version 2 board)
Unit 4 – Connecting to external components
Unit 5 – Micro:bit Music
Unit 6 – Plant Monitoring System & Student Final Project Showcase

Unit 1 will give an introduction to micro:bit hardware and block coding, while Unit 2 will focus on the usage of micro:bit built-in sensors in the Internet of Things (IoT). In Unit 3, students learn about sound and touch sensors and their practical applications, followed by an introduction to physical computing and IoT principles in Unit 4. This unit involves connecting micro:bit board with different electronic components and sensors.
Unit 5 focuses on Micro:bit Music and the integration of micro:bits with external components from the Tinker Kit. Lastly, Unit 6 emphasizes the use of a plant monitoring device in urban farming and its connection to the United Nations' Zero Hunger goal. Upon completing the course, students will need to work on their final projects to demonstrate their acquired knowledge on micro:bit coding.

1.6 Nature of STEAM Activity

Element	Description	Composition
Science	Physics: music frequency, and electricity	✪✪
Technology	Computational thinking through coding	✪✪✪✪
Engineering	Hands-on Practice with electronic circuit	✪✪✪
Arts	Design your own prototype and showcase	✪
Mathematics	mathematical logics	✪

1.7 Mapping of Key Learning Areas (KLAs)

Unit	Science Education	Technology Education	Mathematics Education	Arts Education
1		◆ Problem solving procedures and techniques (TK2.1) ◆ Data manipulation (TK2.3)		
2		◆ Problem solving procedures and techniques (TK2.1) ◆ Data manipulation (TK2.3)		
3		◆ Problem solving procedures and techniques (TK2.1) ◆ Data manipulation (TK2.3) ◆ Family relationship (TK14.3)		
4	◆ Electric current (SP4.2.1) ◆ Simple circuits (SP4.2.5)	◆ Problem solving procedures and techniques (TK2.1) ◆ Data manipulation (TK2.3)		

Unit	Science Education	Technology Education	Mathematics Education	Arts Education
5	◆ Wave nature of sound (SP3.3.1) ◆ Musical notes (SP3.3.3)	◆ Problem solving procedures and techniques (TK2.1) ◆ Data manipulation (TK2.3)		
6		◆ Problem solving procedures and techniques (TK2.1) ◆ Data manipulation (TK2.3) ◆ Mechanical, electrical, electronic and pneumatic control systems (TK9.4) ◆ Change in lifestyles (TK4.7)		

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
1	Introduction to micro:bit	180 mins
2	Micro:bit Sensors	180 mins
3	Micro:bit Sensors (for version 2 board)	90 mins
4	Connecting to external components	90 mins
5	Micro:bit Music	120 mins
6	Plant Monitoring System & Student Final Project Showcase	210 mins
	Total	**14 hours 30 mins**

*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

Micro:bit is an educational tool designed to introduce young individuals to the basics of coding and invention. It's a compact, credit card-sized microcontroller with buttons, lights, and internal sensors that makes learning coding an interactive experience.

The micro:bit platform provides students with a comprehensive introduction to the basics of coding and STEAM education. The hands-on project based approach to STEAM education engages and motivates students, and helps them develop a deeper understanding of coding and technology. Teachers will help the students learn by guiding them through different activities and lessons. The goal is to give students hands-on experience with electronics and coding, so by the end of the course, they have a strong understanding of how to use the micro:bit to apply in real-life applications.

The module is divided into six units, each building upon the previous one. Throughout the module, students are encouraged to brainstorm real-life projects and apply their knowledge in interactive discussions and hands-on projects.

Unit 1 provides a basic introduction to micro:bit hardware and block coding, while Unit 2 focuses on micro:bit built-in sensors and their role in the Internet of Things (IoT). Unit 3 teaches about the sound and touch sensors and their practical applications, while Unit 4 introduces students to physical computing and IoT principles. Students will connect micro:bit to different electronic components. Unit 5 focuses on Micro:bit Music and connecting micro:bits to external components in the Tinker Kit. Finally, Unit 6 emphasizes the use of a plant monitoring device in urban farming with the sensors and its connection to the United Nations' goal of Zero Hunger.

By the end of the module, students will need to work on their final project showcase to demonstrate their knowledge learned with the micro:bit projects. The course provides a foundation for future studies in computer science or engineering fields and enhances problem-solving skills of students.

2.1 Unit 1: Introduction to Micro:bit

Unit 1 covers the basics of STEAM Education and Micro:bit coding. This unit introduces makecode.microbit.org as a coding platform to write simple block code language to give instructions to the micro:bit board. Students will have hands-on projects to understand the basic coding on micro:bit.

2.1.1 Objectives

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

- Describe the concepts of electromagnetic radiation
- Identify corresponding wavelengths and frequencies of different electromagnetic radiations
- List out the applications of different electromagnetic radiations
- Briefly explain the working mechanisms of the the applications

2.1.2 Pre-requisite (if appropriate)

Nil.

2.1.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction: ◆ Teacher briefs about STEAM education, and the importance of coding and innovation. ◆ Arouse students' interest in STEAM education by introducing micro:bit board ◆ Students look at the micro:bit board and able to know the basic hardware components (e.g. buttons, LEDs)	30 mins	◆ PowerPoint slides ◆ Micro:bit
(2) Your First Program ◆ To introduce a make code platform (http://makecode.microbit.org) students ◆ To teach students the logic of coding ◆ To teach students to write the first program with micro:bit ◆ To teach students how to download the coding to their micro:bit	30 mins	◆ PowerPoint slides
(3) Coding with Buttons ◆ Featured Project #2: Game: Rock Paper Scissors ◆ To teach students how to use the event to code the game	30 mins	◆ PowerPoint slides
(4) Randomness & Variable ◆ Featured Project #3: Random Number Generator ◆ To teach students how to use "shake" to generate a random number ◆ Featured Project #4: Dice ◆ To teach students how to use "variable" and "If-then" condition	60 mins	◆ PowerPoint slides
(5) Discussion: ◆ Encourage students to brainstorm real-life projects with micro:bit ◆ Debriefing	30 mins	◆ PowerPoint slides ◆ Notes
Total	**180 mins**	

2.1.4 Assessment (if appropriate)

- Student's knowledge of the nature of EM radiation and will be assessed through polling and multiple-choice questions
- Student's knowledge of the science behind each application of EM radiation will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.2 Unit 2: Micro:bit Sensor

Sensors are becoming increasingly important in real life applications due to advancements in technology and the rise of the Internet of Things (IoT). Sensors can detect and measure physical phenomena such as light, temperature, sound, and movement, and the data they collect can be used to automate processes, make decisions, and enhance user experiences.

With the help of coding, this data can be analyzed and used to control devices connected to the IoT. As sensors continue to become smaller, cheaper, and more sophisticated, they are being integrated into an ever-growing range of devices and systems, making them a crucial component in the connected world we live in today. Understanding sensors and their role in the IoT is a key aspect of modern education, particularly for students who are interested in technology and coding.

2.2.1 Objectives

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

- Understand the unique features of UV radiation
- List out different applications of UV radiation
- Describe briefly the working mechanisms of each application introduced
- Explain why UV are used for the corresponding applications

2.2.2 Pre-requisite (if appropriate)

Nil.

2.2.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) What is a sensor: ◆ To explain sensors in real life application ◆ To explain temperature sensor in micro:bit ◆ Featured Project #1: Measuring room temperature	30 mins	◆ PowerPoint slides ◆ Micro:bit
(2) Light sensor: ◆ Featured Project #2: Night light	30 mins	◆ PowerPoint slides

Description	Duration (hr/min)	Resources
(3) Accelerometer: ◆ What is an Accelerometer ◆ Featured Project #3: Be a little pilot (Game)	30 mins	◆ PowerPoint slides
(4) Other sensors: ◆ Featured Project #4: Compass ◆ Featured Project #5: Detecting magnetic force	30 mins	◆ PowerPoint slides ◆ Magnetic bar
(5) Students Project: ◆ To led students to brainstorm how to solve daily life problem using sensors and micro:bit	60 min	◆ PowerPoint slides
Total	**180 mins**	

2.2.4 Assessment (if appropriate)

- Student's knowledge and understanding of the working principles, scientific explanations and the corresponding features of UV radiation will be assessed through polling and multiple-choice questions
- Overall students' participation would be reviewed

2.3 Unit 3: Micro:bit Sensors (For version 2 board)

The objective of learning the micro:bit sensor is to empower teachers with the skills to integrate technology into their classroom and enhance the learning experience of students. With micro:bit sensors, teachers can create engaging hands-on projects that not only teach coding but also real-life applications of technology.

The sound sensor can be used to detect the sound that responds to different levels of sound input. The touch sensor, on the other hand, can be used to create interactive games or control devices by touch. These sensors can also be used to teach students about sound and touch technology, as well as their applications in real life.

As a teacher, it's important to encourage your students to actively engage in discussions about the usage of micro:bit sensors. By promoting an interactive learning environment, students are given the opportunity to explore new concepts, ask questions, and gain a deeper understanding of the topic at hand. By facilitating discussions on micro:bit sensor usage, students will develop critical thinking skills, collaborate with their peers, and deepen their knowledge of the subject matter.

2.3.1 Objectives

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

- List out the unique properties and types of UV
- Make a DIY UV-box
- Design the DIY UV-box
- Pay attention to the safety issues of using UV radiation

2.3.2 Pre-requisite (if appropriate)

Nil.

2.3.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction: ◆ To introduce the differences between micro:bit v1 and v2 ◆ To explain the learning objectives of this lesson	10 mins	◆ PowerPoint slides
(2) Sound Sensor: ◆ What is sound sensor ◆ Featured Project: Sound sensor alert	25 mins	◆ PowerPoint slides
(3) Touch Sensor: ◆ What is touch sensor ◆ Featured Project: Doorbell ◆ To introduce the mechanism of the doorbell ◆ To encourage students' discussion on sensor applications in real life	25 mins	◆ PowerPoint slides
(4) Discussion: ◆ To suggest how the other micro:bit components can be applied to make a new invention	30 mins	◆ PowerPoint slides ◆ Notes
Total	**90 mins**	

2.3.4 Assessment (if appropriate)

- Student's knowledge of the nature of EM radiation and will be assessed through polling and multiple-choice questions
- Student's knowledge of the science behind each application of EM radiation will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.4 Unit 4: Connecting to External Components

With the rapid advancement of technology, it is becoming increasingly important for students to have a basic understanding of how technology interacts with the physical world.

Micro:bit provides a platform for students to explore this interaction and develop the skills necessary to create interactive projects that connect to external components.

Building a simple traffic light system is a great way for students to apply their knowledge and understanding of digital pins, which are a fundamental concept in physical computing and IoT. This hands-on experience will also help students to develop problem-solving skills, as they troubleshoot any issues that may arise during the project. Students will gain a strong foundation in physical computing and IoT principles, preparing them for future studies in related fields.

2.4.1 Objectives

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

- Use the DIY UV-box for disinfection and visualization purposes
- Conduct the ATP-bacteria test
- Conduct gel electrophoresis
- Use thin layer chromatography

2.4.2 Pre-requisite (if appropriate)

Nil.

2.4.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Micro:bit Tinker Kit: ◆ What are Electricity and circuit ◆ To explain what is digital pins ◆ To introduce micro:bit breakout board ◆ Overview of Tinker Kit	30 min	◆ PowerPoint slides
(2) External LEDs: ◆ Featured Project #1: LED on/off ◆ Featured Project #2: Traffic light	30 min	◆ PowerPoint slides ◆ Micro:bit ◆ Tinker kit set
(3) Discussion: ◆ To encourage students to discuss how improve the existing traffic light by using different sensors and coding	30 min	◆ PowerPoint slides ◆ Activity 1
Total	**90 min**	

2.4.4 Assessment (if appropriate)

- Student's knowledge of the nature of EM radiation and will be assessed through polling and multiple-choice questions
- Student's knowledge of the science behind each application of EM radiation will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.5 Unit 5: Micro:bit Music

This unit is designed specifically to deepen students' understanding of frequency, with a focus on piano frequency. They will learn about the science behind sound production and the crucial role frequency plays in determining the tone of sound.
In addition to frequency, students will also study analog writing, which involves adjusting the brightness level of LED lights by changing their analog values. This connection between theory and practical applications in the real world will be emphasized.

The unit consists of four interactive projects that reinforce students' learning and comprehension of the topics covered. These include:

1. A musical box using micro:bit music blocks and a buzzer
2. Controlling LED light levels through analog writing
3. Using analog reading to produce a changing sound with a potentiometer
4. A piano built with an ADKeyboard, showcasing the students' newfound knowledge and skills.

Upon completion of the unit, students will have a comprehensive understanding of frequency, analog signals, and practical experience connecting micro:bit components with the tinker kit set. The course content will be both educational and enjoyable, leading to a greater appreciation for the world of sound and technology.

2.5.1 Objectives

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

- List out the unique properties and types of UV
- Make a DIY UV-box
- Design the DIY UV-box
- Pay attention to the safety issues of using UV radiation

2.5.2 Pre-requisite (if appropriate)

Nil.

2.5.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Sound: ◆ What is Frequency ◆ To teach students about piano Frequency	30 mins	◆ PowerPoint slides ◆ Micro:bit ◆ Tinker Kit
(2) Music on micro:bit: ◆ Featured Project #1: Music Box	30 mins	◆ PowerPoint slides

Description	Duration (hr/min)	Resources
(3) Digital vs Analog: ◆ Featured Project #2: Light??? ◆ Potentiometer ◆ Featured Project #3: Magic Bell (Changing sound)	30 mins	◆ PowerPoint slides
(4) ADKeyboard: ◆ To introduce the function of "Extension" ◆ Featured Project #4: Piano	30 mins	◆ PowerPoint slides ◆ Notes
Total	**120 mins**	

2.5.4 Assessment (if appropriate)

- Student's knowledge of the nature of EM radiation and will be assessed through polling and multiple-choice questions
- Student's knowledge of the science behind each application of EM radiation will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.6 Unit 6: Plant Monitoring System

Urban farming is a crucial aspect of sustainable food production and addressing food insecurity in urban areas. In this unit, students will learn about the connection between urban farming and the United Nations' goal of Zero Hunger, as well as the use of a plant monitoring device in urban farming.

The class emphasizes a hands-on approach and utilizes micro:bit and soil sensors in the project to provide students with practical experience in the field. Not only will students gain a better understanding of the technology used in modern urban farming practices, but they will also have the opportunity to learn and practice coding with micro:bit and soil sensors.

By the end of the class, students will have a deeper appreciation for the role of urban farming in meeting the food needs of communities, and will have gained valuable coding experience with soil sensors and coding in general.

2.6.1 Objectives

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

- List out the unique properties and types of UV
- Make a DIY UV-box
- Design the DIY UV-box
- Pay attention to the safety issues of using UV radiation

2.6.2 Pre-requisite (if appropriate)

Nil.

2.6.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Urban Farming: ◆ What is United Nation Goals: Zero Hunger ◆ Urban Farming	30 mins	◆ PowerPoint slides ◆ Micro:bit
(2) Plant Monitoring Device: ◆ -	90 mins	◆ PowerPoint slides
(3) Final Project Showcase: ◆ -	60 mins	◆ PowerPoint slides
(4) Debriefing: ◆ ???	30 mins	◆ PowerPoint slides ◆ Notes
Total	**210 mins**	

2.6.4 Assessment (if appropriate)

- Student's knowledge of the nature of EM radiation and will be assessed through polling and multiple-choice questions
- Student's knowledge of the science behind each application of EM radiation will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

3 Resources

3.1 Resources for Unit 1

- Teachers' Guide
- PowerPoint slides
- Notes
- Materials (micro:bit board, USB cable)
- Computer laptop / desktop with Google Chrome Browser installed

3.2 Resources for Unit 2

- Teachers' Guide
- PowerPoint slides
- Activity book
- Notes
- Materials (micro:bit board, USB cable)
- Computer laptop / desktop with Google Chrome Browser installed

3.3 Resources for Unit 3

- Teachers' Guide
- PowerPoint slides
- Online videos
- Activity book
- Notes
- Materials (micro:bit board, USB cable)
- Computer laptop / desktop with Google Chrome Browser installed

3.4 Resources for Unit 4

- Teachers' Guide
- PowerPoint slides
- Activity book
- Notes
- Materials (micro:bit board, USB cable)
- Computer laptop / desktop with Google Chrome Browser installed

3.5 Resources for Unit 5

- Teachers' Guide
- PowerPoint slides
- Activity book
- Notes
- Materials (micro:bit board, USB cable)

- Computer laptop / desktop with Google Chrome Browser installed

3.6 Resources for Unit 6

- Teachers' Guide
- PowerPoint slides
- Activity book
- Notes
- Materials (micro:bit board, USB cable)
- Computer laptop / desktop with Google Chrome Browser installed

4 References

Curriculum Development Council & Hong Kong Examinations and Assessment Authority (2007). *Mathematics Education Key Learning Area: Technology and Living -Curriculum and Assessment Guide (Secondary 4 - 6).* Hong Kong: Government Logistics Department. Retrieved November, 2015, from https://334.edb.hkedcity.net/new/doc/eng/curriculum2015/TL_CAGuide_e_2015.pdf

Curriculum Development Council & Hong Kong Examinations and Assessment Authority (2007). *Science Education Key Learning Area: Physics - Curriculum and Assessment Guide (Secondary 4 - 6).* Hong Kong: Government Logistics Department. Retrieved November, 2015, from https://334.edb.hkedcity.net/new/doc/chi/curriculum2015/Phy_CAGuide_c_2015.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://334.edb.hkedcity.net/new/doc/eng/curriculum2018/Chem_C&A_Guide_updated_Eng_22082018.pdf

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 June, 2018, from https://334.edb.hkedcity.net/new/doc/chi/curriculum2015/Bio_CAGuide_e_2015.pdf

Curriculum Development Council & Hong Kong Examinations and Assessment Authority (2007). *Science Education Key Learning Area: Mathematics - Curriculum and Assessment Guide (Secondary 4-6).* Hong Kong: Government Logistics Department. Retrieved December, 2017, from https://334.edb.hkedcity.net/new/doc/eng/curriculum2017/Math%20C%26A%20Guide_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://334.edb.hkedcity.net/new/doc/eng/curriculum2018/CS_C&A_Guide_updated_Eng_22082018.pdf