Jockey Club STEAM Education Resources Sharing Scheme

To be a Doctor in Cooking

Teachers' Guide

First Edition January 2021

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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 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 integrate knowledge and skills across Science, Technology, Engineering, Arts and Mathematics under real-world contexts.

1 Module Outline

1.1 Module Title: To Be a Doctor in Cooking

Have you ever been curious about what is happening during rice cooking or meat grilling? A subject called Molecular Gastronomy can help you. As a scientific discipline, molecular gastronomy is about studying and investigating the physics and chemistry behind cooking. Thanks to Hervé This, a physical chemist, and Nicholas Kurti, a former professor of physics at the University of Oxford, who first introduced molecular gastronomy in 1988, a lot of traditional techniques for cooking had been investigated and explained. Nowadays, many new culinary styles, for example, molecular cuisine, are created based on such techniques and scientific principles.

There are numerous basic food preparation and cooking techniques such as boiling, roasting, frying, fermentation, baking and emulsification. These processes are applied science. The conditions of the processes are not just arbitrarily set but can be explained by biology, chemistry and physics. There are many physical changes during cooking, and chemical reactions give different observations, such as changes in the colour, volume, smell, and texture of food.

In this module, how the human body responds to different chemicals in food, in this case, smell and taste, will be introduced. Scientific knowledge and working principles of traditional cooking techniques will be covered. Some state-of-the-art cooking methods, such as molecular cooking and 3D food printing, will also be included. At the end of the module, students would have experience in molecular cooking.

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 "*To be a Doctor in Cooking*" aims to:

- Introduce how the human body responds to different chemicals in food (smell and taste)
- Raise students' awareness of the scientific knowledge and working principles of food preparation and cooking techniques used in daily life
- Introduce new cooking techniques such as molecular cooking methods and 3D food printing to students
- Advance students' application of subject knowledge and skills learned in the school curriculum of junior and senior secondary Science and Biology, Chemistry and Physics

1.4 Module Learning Outcomes

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

- List out different chemical compositions in food
- Describe how the human nervous system responds to different chemicals in food
- Understand the scientific knowledge and working principles of food preparation and traditional cooking techniques
- Use chemical and physical theories to explain different observations or changes in food during cooking
- Prepare soufflé pancake or basic molecular cuisine

1.5 Learning & Teaching Approach / Practice

Food preparation and cooking are essential skills for humans to survive and can be an enjoyment or a hobby. However, cooking is seldom treated as a scientific discipline to be taught in secondary and tertiary education. When you are cooking, you apply different concepts and principles of biology, chemistry and physics in the kitchen. Each time you try a new recipe (experimental), you first prepare different food and seasoning (chemicals and substrates). When you are cooking, you make observations and taste the food (testing and characterisation) and finally conclude how the food can taste better in your next attempt (creating a hypothesis). Thus, using cooking as an example to introduce and explain different concepts and theories of biology, chemistry and physics could be a more effective way for students to master the knowledge. As STEAM education encourages students to think critically and emphasises problem-solving skills, this module will adopt a problem-based learning approach to explain different observations in daily life and solve real-life problems.

After introducing all necessary knowledge in Units 1 to 3, students would have a chance to apply their knowledge for preparing dishes by using molecular cooking methods in Unit 4.

At the end of the module, students will increase their understanding of the 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	Food compositions, the sensory system in the human body for taste and smell, physical changes and chemical reactions happened during cooking	✪✪✪✪✪
Technology	Explore the most advanced food preparing and cooking technologies	✪✪✪
Engineering	Understand the working principles of different food preparation and cooking apparatus such as the aging chamber, air fryer and 3D food printer	✪✪✪

Element	Description	Composition
Arts	Design the shape and appearance of molecular cuisine	✪✪✪
Mathematics	Calculate and design the nutrients composition of cuisine	✪✪

1.7 Mapping of Key Learning Areas (KLAs)

Unit	Science Education	Technology Education	Mathematics Education	Arts Education
1	◆ Nutrition in humans (SB3.2) ◆ Chemical structures of macronutrients ◆ Coordination and response (SB3.4) ◆ Acids and Bases (SC4.2) ◆ Smell and taste (SJ10.4)	◆ Dietary goals and eating habits (TK10.7) ◆ Food groups (TK10.8)		
2	◆ Use of microorganisms (SB7.2) ◆ Fossil fuels and carbon compounds (SC5.2) ◆ Microscopic world II (SC6.2) ◆ Chemistry of carbon compounds (SC11.3) ◆ Change of state (SP1.3.1) ◆ Electricity at home (SP8.1.3) ◆ Dissolving (SJ6.3)	◆ Food preparation and processing (TK11.2, 11.3, 11.6, 11.8, 11.9) ◆ Food technology (TK15.5, 15.8)		

Unit	Science Education	Technology Education	Mathematics Education	Arts Education
3		◆ Production processes in various fields (TK6.3) ◆ Meal planning (TK10.9) ◆ Food technology (TK15.8)		
4		◆ Operations and manufacturing (TK6.2)	◆ Using percentages (MJ5.1, 5.2) ◆ Rates, ratios and proportions (MJ6.1, 6.2)	◆ Cooking and designing the appearance of molecular cuisine

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	How chemicals in food can be detected by the sensory system in the human body	120 mins	Worksheets, lab reports and presentation
2	Scientific knowledge and working principles of food preparation and cooking techniques	120 mins	
3	Diverse dishes prepared and cooked by different methods and techniques	130 mins	
4	Cooking of molecular cuisine	120 mins	
	Total	**8 hours 10 mins**	

1.9 Thematic Area

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

2 Module Design

Food preparation and cooking are essential skills for humans to survive and can be an enjoyment or a hobby. However, cooking is seldom treated as a scientific discipline to be taught in secondary and tertiary educations. When you are cooking, you apply different concepts and principles of biology, chemistry and physics in the kitchen. There are numerous basic food preparation and cooking techniques such as boiling, roasting, frying, fermentation, baking and emulsification. These processes are applied science. The conditions of the processes are not just arbitrarily set but can be explained by biology, chemistry and physics. There are many physical changes and chemical reactions during cooking, which give different observations, such as changes in the colour, volume, smell, and texture.

Students are expected to have basic knowledge of food compositions and how the human body responds to taste and smell. Unit 1 will familiarise students with food compositions such as carbohydrates, lipids and proteins. The physiology of taste, smell, and flavour will also be introduced in Unit 1.

In Unit 2, scientific knowledge and working principles of cooking techniques such as steaming, baking, roasting, pan-frying, and molecular cooking will be introduced. Chemical reactions and observations during cooking such as browning, expanding, foaming and softening will be explained using knowledge of chemistry and physics.

In Unit 3, different dishes such as steak, bread, soufflé and beer will be used to illustrate how food preparation and cooking techniques mentioned in Unit 2 are applied in our daily life.

In Unit 4, students will design and cook soufflé or molecular cuisine. A chance will be provided for them to have hands-on experience in different cooking methods.

2.1 Unit 1: Taste and smell

In order to create appealing dishes, one should know how different chemicals would impact the flavours of food and drinks. Carbohydrates, lipids and proteins are the most commonly found chemicals in different food. In the human body, there are different receptors responsible for these chemicals and sending different signals to our brains to tell how great a dish or beverage tastes. What we are commenting on is the flavour of the food. The origin of flavours is the combination of taste and smell sensations received by the human brain when eating and drinking. Therefore, sensory receptors, the nervous system and the brain are important for humans to truly enjoy the flavours of food.

In this unit, chemical compounds and structures such as macro- and micronutrients will be introduced. The physiology of taste, smell, and flavour will also be included.

This unit would familiarise students with how chemicals in food can be detected by the sensory system in the human body, which is necessary for students to understand Unit 2.

2.1.1 Objectives

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

- List out the macro- and micronutrients found in food
- Identify the chemical structures of macronutrients
- Define what taste, smell and flavour are
- Identify different tastes and smell receptors and related cells and nerve fibres
- Understand how taste, smell and flavour are perceived in the human body

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) Macro- and micronutrients found in food: ◆ To introduce the chemical structures of macronutrients ◆ To introduce different micronutrients ◆ Ask students to list out the essential nutrients	15 mins	◆ PowerPoint slides
(3) Definition of taste, smell and flavour ◆ To define taste, smell and flavour ◆ To define five distinct classes of tastants ◆ To introduce sensory receptors responsible for different tastants and odorants	25 mins	◆ PowerPoint slides
(4) Perception of taste, smell and flavour in the human body: ◆ To introduce the basics of taste ◆ To explain how different tastants are perceived in the human body ◆ To introduce an olfactory system for smell ◆ To explain how the system detects odorants	60 mins	◆ PowerPoint slides ◆ Activity 1
(5) 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)

- Student's knowledge of the definitions and structures of macro- and micronutrients will be assessed through polling and multiple-choice questions
- Student's knowledge of how taste, smell and flavour are perceived in the human body will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.2 Unit 2: The Science of Food Preparation and Cooking Techniques

After introducing tastants and odorants and how they are detected in the human body in Unit 1, their identity, chemical structure, and production during cooking will be illustrated. In addition, cooking techniques that chefs or bakers use to create particular flavours and textures of food and dishes will also be discussed. Different physical changes in food and chemical reactions happened during cooking, and the explanations will be covered.

In Unit 2, scientific knowledge and working principles of food preparation and cooking techniques such as boiling, melting, roasting, frying and molecular cooking will be introduced. Physical changes, chemical reactions and observations during cooking such as browning, expanding, foaming and softening will be explained using knowledge of chemistry and physics. Students are expected to understand different cooking methods from a scientific point of view. This unit paves the road for understanding Unit 3 and Unit 4.

2.2.1 Objectives

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

- Identify different food preparation and cooking techniques
- Understand the working principles of the processes and techniques
- Explain the physical and chemical changes in food during cooking
- List out the purposes of using different food preparing and cooking methods

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) Cooking techniques: ◆ To introduce different techniques such as boiling, melting, roasting and frying ◆ To describe the working principles of the techniques ◆ To explain the physical and chemical changes during cooking ◆ To discuss the purposes of applying the techniques	50 mins	◆ PowerPoint slides
(3) Food preparing process: ◆ To introduce different molecular cooking processes such as sous vide, emulsification and foaming ◆ To describe the working principles of the processes ◆ To explain the physical and chemical changes during the processes ◆ To discuss the purposes of the processes	50 mins	◆ PowerPoint slides ◆ Activity 2
(4) Debriefing: ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	10 mins	◆ PowerPoint slides ◆ Notes
Total	**120 mins**	

2.2.4 Assessment (if appropriate)

- Student's knowledge and understanding of the working principles, scientific explanations and purposes of different food-preparing processes will be assessed through polling and multiple-choice questions
- Student's knowledge and understanding of the working principles, scientific explanations and purposes of different cooking techniques will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.3 Unit 3: Dishes and Drinks

In Units 1 and 2, students are familiarised with flavouring, food preparation and cooking techniques. These are all essential elements for understanding the science behind different dishes such as steak, bread, soufflé, beer and wine. Usually, to make a delicious dish, a series of food preparation processes and cooking methods are integrated and utilised to create new and pleasant tastants, odorants and textures. Indeed, extra physical changes in food can be observed, and different chemical reactions might also be involved.

In this unit, different cooking processes will be highlighted. The science behind the processes, physical and chemical changes, will be explained based on physical and chemical theories.

2.3.1 Objectives

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

- Identify various food preparing and cooking techniques used to prepare different dishes
- Describe briefly why a particular process is used to prepare a particular dish
- Explain the physical and chemical changes of food observed during different dishes preparation
- Design a molecular cuisine by using different molecular cooking methods

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) Steak and soufflé: ◆ To introduce the corresponding dishes' preparation and cooking techniques involved ◆ To describe the working principles of the above processes ◆ To explain the physical and chemical changes observed during the processes	30 mins	◆ PowerPoint slides
(3) Bread, beer and wine: ◆ To introduce the corresponding dishes' preparation and cooking techniques involved ◆ To describe the working principles of the above processes ◆ To explain the physical and chemical changes observed during the processes	50 mins	◆ PowerPoint slides ◆ Online videos

Description	Duration (hr/min)	Resources
(4) Design of molecular cuisine: ◆ To introduce different molecular cooking methods ◆ To describe the working principles of the methods ◆ To explain the science behind the methods ◆ To encourage students to design a molecular cuisine which will be prepared and made in Unit 4	30 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	**130 mins**	

2.3.4 Assessment (if appropriate)

- Student's knowledge and understanding of the working principles of dishes preparation, scientific explanations behind the preparing procedures and purposes and effects of different food preparing processes and cooking methods will be assessed through polling and multiple-choice questions
- Student's knowledge and understanding of molecular cooking methods will be assessed through the pre-lab report
- Overall students' participation would be reviewed

2.4 Unit 4: Making Soufflé Pancake or Molecular Cuisine

To have a more comprehensive understanding of making soufflé pancakes and molecular cuisine, students should have basic knowledge of flour composition, foaming process, Maillard reactions, and molecular cooking methods introduced and covered in Units 1, 2 and 3.

In this unit, students with prior knowledge are expected to make a soufflé pancake and molecular cuisine. By using flour, egg and oven, students will have a chance to make a soufflé pancake and design it by themselves. For molecular cuisine, techniques such as spherification, reverse spherification, emulsification and gelation will be used to make and design their own molecular cuisine. Students are also expected to explain the physical and chemical changes observed during the processes. Finally, students will be encouraged to share their ideas and think about their own artwork.

2.4.1 Objectives

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

- Make a soufflé pancake or molecular cuisine
- Describe why different reagents, ingredients and procedures are applied during the cooking
- Explain the physical and chemical changes observed during the cooking processes
- Appreciate other students' dishes from an artistic and a scientific point of view

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) Safety instruction: ◆ Mention the safety issue of using different apparatus such as blenders and cookers or heaters	10 min	◆ PowerPoint slides
(3) Experiment section: ◆ To brief students on the procedures of the experiment ◆ To guide students to finish the experiment ◆ Students design the appearance of their dishes	60 min	◆ PowerPoint slides ◆ Activity 3 or 4
(4) Tasting section: ◆ To present the dishes ◆ To taste different dishes created by students ◆ Students and the teacher comment on and appreciate others' works from an artistic and a scientific point of view	20 min	◆ PowerPoint slides ◆ Notes
(5) Debriefing: ◆ To review the knowledge covered in all units	20 min	◆ PowerPoint slides ◆ Notes
Total	**120 min**	

2.4.4 Assessment (if appropriate)

- Students' scientific knowledge and understanding of the working principles of foaming, Maillard reactions and molecular cooking will be assessed through polling and multiple-choice questions

- Student's cooking and laboratory performance will be assessed through the laboratory session
- 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
- 3D food printer
- Activity book
- Notes

4 References

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