Jockey Club STEAM Education Resources Sharing Scheme

The Next Masterchef: 3D Food Printing

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, 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: The Next Masterchef: 3D Food Printing

Compared with classic cooking methods, 3D food printing is a novel technology to prepare food via additive manufacturing. With all food-grade parts used, the ordinary 3D printer can be transformed into a 3D food printer. By utilising "edible ink" such as chocolate, cheese, jelly and frosting, food products with sophisticated shapes and designs which cannot be easily accomplished by handmade skills can be made. Recently, 3D food printing has been used to prepare personalised meals for people, especially the elderly, who have different nutrition requirements and nutrition-related diseases such as diabetes, obesity and high blood pressure.

To design printed food, one should have basic knowledge of the essentials of human nutrition. Functions of macronutrients such as carbohydrates, lipids and protein and micronutrients such as minerals and vitamins are covered in junior and senior secondary school Science and Biology syllabi for a long time. However, there is a lack of interesting applications to be used to share knowledge with students. 3D food printing could be a solution to the issue.

Special knowledge such as the working principle of a food printer, food composition labelling and dietary assessment would be covered in this module. At the end of the module, students would have experience in designing printed food.

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 "*The Next Masterchef: 3D Food Printing*" aims to:

- Introduce basic human nutrition to students
- Raise students' awareness of the nutrients composition of food consumed in daily life
- Introduce 3D food printing technology to students
- Advance students' application of subject knowledge and skills learned in the school curriculum of the Senior Secondary (SS) Science and SS Biology

1.4 Module Learning Outcomes

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

- List out the essential nutrients for the human being
- Describe the nutrients composition of food consumed in daily life
- Advise different kinds of food to people with different nutrition requirements
- Understand the working principle of a 3D food printer
- List out the applications of 3D food printing technology
- Create printed food by using a 3D food printer

1.5 Learning & Teaching Approach / Practice

For a long time, human nutrition science has been taught using memorisation strategies that might prevent students from becoming the true owners of comprehensive knowledge. Applying knowledge to solve real-life problems, instead of memorising solely, could be a more effective way for students to master the knowledge. As STEAM education encourages students to have critical thinking and emphasises problem-solving skills, this module will adopt a problem-based learning approach to solve real-life problems.

After introducing all necessary knowledge in Units 1 to 3, students would have a chance to apply their knowledge when assigned a case study on an infant or elderly's nutrition requirements in Unit 3. Students will be asked to design printed food with suitable nutrient composition using a 3D food printer in Unit 4.

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

1.6 Nature of STEAM Activity

Element	Description	Composition
Science	Basic food and human nutrition knowledge of SS Science and Biology	✪✪✪✪
Technology	Explore the most advanced food printing technologies	✪✪✪✪
Engineering	Understand the working principle of 3D food printer	✪✪✪
Arts	Design the shape and appearance of printed food	✪✪
Mathematics	Calculate and design the nutrients composition of printed food	✪✪✪

1.7 Mapping of Key Learning Areas (KLAs)

Unit	Science Education	Technology Education	Mathematics Education	Arts Education
1	◆ Nutrition in humans (SB3.2) ◆ Macronutrients (TK10.5) ◆ Micronutrients (TK10.8) ◆ Chemical structures of macronutrients			
2	◆ Nutrition and health (SJ12.2) ◆ Food pyramids, balanced diet (TK10.1) ◆ Body building food, the food label requirement (TK10.2) ◆ Nutrition labels (TK10.4)	◆ Dietary goals and eating habits (TK10.7) ◆ Food groups (TK10.8) ◆ Dietary goals and eating habits (TK10.7)	◆ Measures of dispersion (MS17.6)	
3		◆ The production process in various fields (TK6.3) ◆ Meal planning (TK10.9) ◆ Food technology (TK15.5) ◆ Food product development (TK15.8)		
4		◆ Food printing technology		◆ Design the appearance of printed food

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	Essential Nutrition for Human	110 mins	Worksheets, project reports and presentation
2	Nutritional Values and Food Composition Labelling	110 mins	
3	The Working Principle and Applications of 3D Food Printing and Case Study	120 mins	
4	Food Printing by Using a 3D-Food Printer	120 mins	
	Total	**7 hours 40 mins**	

1.9 Thematic Area

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

2 Module Design

Recently, a report about food printing market trends has been published by Research and Markets. The report provides estimates for 2020 and 2025 by using 2019 as a base year. It estimates that the global 3D food printing market should grow from $485.5 million in 2020 to $1 billion by 2025. 3D food printing is believed to revolutionise the restaurant industry in the future, and more 3D food printing restaurants will be opened around the world. The report shows that 3D food printing is getting more and more mature and popular throughout the world. Therefore, there are advantages for students to have a basic understanding of 3D food printing technology and hands-on experience in food printing.

In order to create and make printed food, students are expected to have basic knowledge of food and nutrition, and 3D food printing technology. Unit 1 and Unit 2 will familiarise students with the essential nutrition of humans, food compositions and nutritional values. Marco- and micronutrients, daily nutrition requirements and food labels will be introduced in Unit 1 and Unit 2.

In Unit 3, the working principle of 3D food printing technology will be illustrated. Three important food printing areas will be explored, including materials/ingredients, process parameters and post-processing methods. Applications and future development of 3D food printing will also be discussed. After that, students will be given a case study on the nutrition requirements of infants or elderly. Students with prior knowledge are expected to design printed food based on the nutrition requirements indicated in the case study.

In Unit 4, students will make the printed food they designed by using a 3D food printer. A chance will be provided for them to operate a 3D food printer and finally, printed food with a customised nutrient composition and unique appearance will be created.

2.1 Unit 1: Essential Nutrition for Human

Human nutrition is a scientific discipline of the physiological and biochemical processes involved in nourishment. These processes describe how chemical compounds in food generate energy or are converted into body tissues.

The essential nutrients which cannot be synthesised at all or in sufficient amounts in the body are needed for humans to survive. In order to design and create healthy printed food, students are expected to have basic knowledge of human nutrition.

In this unit, chemical structures of macro- and micronutrients and how they work in the human body will be introduced. This unit would familiarise students with basic human nutrition which is necessary for students to understand Unit 2.

2.1.1 Objectives

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

- Define what is the essential nutrients of human nutrition
- List out the macro- and micronutrients for human
- Identify the chemical structures of macronutrients
- Understand how macronutrients work in the human body
- Identify micronutrients and their functions in the human body

2.1.2 Pre-requisite (if appropriate)

Nil.

2.1.3 Description of Activity

Description	Duration	Resources
(1) Introduction: ◆ Arouse students' interest in relevant real-life issues. ◆ To explain the learning objectives of this unit.	10 mins	◆ PowerPoint slides
(2) Definition of essential nutrients for humans: ◆ To introduce the definition and illustrate it with examples ◆ Ask students to list out the essential nutrients	15 mins	◆ PowerPoint slides
(3) The chemical structures of macronutrients and their fates in the human body: ◆ To introduce the chemical structures of macronutrients ◆ To briefly explain the digestion, absorption, assimilation and metabolism of macronutrients in the human body ◆ Students are guided to calculate the energy generated by macronutrients	40 mins	◆ PowerPoint slides
(4) Identifying micronutrients and their functions in the human body: ◆ To introduce different micronutrients and their functions in the human body	30 mins	◆ PowerPoint slides
(5) Debriefing: ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	15 mins	◆ PowerPoint slides ◆ Notes
Total	**110 mins**	

2.1.4 Assessment (if appropriate)

- Student's knowledge of the definition of essential nutrients and types of essential nutrients will be assessed through polling and multiple-choice questions
- Student's knowledge of the details of macro-and micronutrients and their functions in the human body will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.2 Unit 2: Nutritional Values and Food Composition Labelling

After introducing essential nutrients in Unit 1, the amounts needed for a human to survive and be healthy will be illustrated. Dietary Reference Values (DRVs) is a nutritional value to estimate the amounts of energy and nutrients needed for different groups of people to be healthy in a population. In this unit, the recommended nutritional values of different macro- and micronutrients will be introduced. How nutritional values are estimated and related to malnutrition diseases will also be discussed.

For students to identify nutrient composition of food consumed in daily life, the Nutrition Facts label which is the most commonly used food composition label around the world will be introduced. The information on the label includes serving information, calories, nutrients and percent daily value. Students are expected to understand the label and use it effectively in their daily life to fulfil their recommended nutrition requirements. This unit paves the road for finishing a case study in Unit 3 and Unit 4.

2.2.1 Objectives

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

- Identify the amounts of energy and different essential nutrients needed for human
- Explain how recommended nutritional requirements/values are estimated
- Understand the Nutrition Facts label
- Use the Nutrition Facts label

2.2.2 Pre-requisite (if appropriate)

Nil.

2.2.3 Description of Activity

Description	Duration	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
(2) Nutritional values and requirements: ◆ To introduce the term "Nutritional values" ◆ To explain how nutritional values are estimated for different nutrients ◆ To illustrate the importance of amounts of nutrients using malnutrition diseases examples	40 mins	◆ PowerPoint slides
(3) The Nutrition Facts label: ◆ To introduce the Nutrition Facts label ◆ To explain what information can be obtained from the label ◆ To demonstrate how the label can be used for nutrition requirements calculation	50 mins	◆ PowerPoint slides ◆ Activity 1
(4) Debriefing: ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	10 mins	◆ PowerPoint slides ◆ Notes
Total	**110 mins**	

2.2.4 Assessment (if appropriate)

- Student's knowledge of the definition of nutritional values and how the values are estimated will be assessed through polling and multiple-choice questions
- Student's knowledge of the Nutrition Facts label and the way to use it will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.3 Unit 3: The Working Principle and Applications of 3D Food Printing and Case Study

Compared with classic cooking methods, 3D food printing is a novel technology to prepare food via additive manufacturing. In principle, with all food-grade parts used, the ordinary 3D printer can be transformed into a 3D food printer. By utilising "edible ink" such as chocolate, cheese, jelly and frosting, food products with sophisticated shapes and designs which cannot be easily accomplished by handmade skills can be made. Recently, 3D food printing has been used to prepare personalised meals for a person,

especially the elderly, who have different nutrition requirements and nutrition-related diseases such as diabetes, obesity and high blood pressure.

In this unit, the working principle of 3D food printing will be introduced, including materials and ingredients, printing techniques and post-processing. Furthermore, current applications of 3D food printing will be discussed.

A case study on the nutrition requirements of the infant or elderly will be given to students. Students with prior knowledge from Unit 1 and Unit 2 are expected to analyse the case and list out the nutrients required according to the case. Students then will design printed food with adequate nutrient composition based on the case study. Students will also design the appearance of printed food.

2.3.1 Objectives

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

- Describe briefly what 3D food printing technology is and how it works
- List out the current applications of 3D food printing technology
- Give a brief nutrition recommendation to people based on their needs
- Design printed food

2.3.2 Pre-requisite (if appropriate)

Nil.

2.3.3 Description of Activity

Description	Duration	Resources
(1) Introduction: ◆ To recap knowledge of the previous lessons ◆ To explain the learning objectives of this lesson	10 mins	◆ PowerPoint slides
(2) The working principle of 3D food printing: ◆ To introduce 3D food printing technology ◆ To describe the working principle including materials and ingredients, printing techniques and post-processing	40 mins	◆ PowerPoint slides ◆ Online videos
(3) Current applications of 3D food printing: ◆ To describe the current applications of 3D food printing ◆ To explain why food printing can be used for the mentioned applications	20 mins	◆ PowerPoint slides ◆ Online videos

Description	Duration	Resources
(4) Case study on nutrition requirements of the infant and elderly: ◆ To guide students to understand the case study ◆ Students are expected to answer and list out the types and amounts of nutrients required by an infant or elderly based on the case study ◆ The answer of the case study (e.g. grams of carbohydrate, proteins and fats) will be used as the nutrient composition to make printed food in Unit 4.	40 mins	◆ PowerPoint slides ◆ Activity 2
(5) Debriefing: ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	10 mins	◆ PowerPoint slides ◆ Notes
Total	**120 mins**	

2.3.4 Assessment (if appropriate)

- Students' knowledge of the working principle of 3D food printing and current applications of it will be assessed through polling and multiple-choice questions
- Students' knowledge of basic human nutrition will be assessed through the case study
- Overall students' participation would be reviewed

2.4 Unit 4: Food Printing by Using a 3D Food Printer

To design and create printed food, students should have basic knowledge of the essentials of human nutrition and the working principle of 3D food printing technology which have been introduced and covered in Units 1, 2 and 3.

Students with prior knowledge are expected to design and create printed food. Students will operate a 3D food printer and print food with customised nutrient composition (from the case study in Unit 3), and a unique appearance will be created. Students will be encouraged to generate a Nutrition Facts label for the printed food.

2.4.1 Objectives

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

- Operate 3D food printer
- Generate printed food with customised nutrients composition
- Design shape and appearance of the printed food
- Create a Nutrition Facts label for the printed food

2.4.2 Pre-requisite (if appropriate)

Nil.

2.4.3 Description of Activity

Description	Duration	Resources
(1) Introduction: ◆ To recap knowledge of the previous lessons ◆ To explain the learning objectives of this lesson	10 mins	◆ PowerPoint slides
(2) Introduction of 3D food printer: ◆ To introduce a 3D food printer ◆ To describe the working principle of the printer briefly	20 mins	◆ PowerPoint slides ◆ Demonstration of 3D Food Printer
(3) Experiment section: ◆ To brief students what is going to do in the experiment ◆ To guide students to finish the experiment ◆ Students design the appearance of printed food ◆ Students comment on and appreciate other's works	60 mins	◆ PowerPoint slides ◆ Activity 3 ◆ Demonstration of 3D Food Printer
(4) Nutrition Facts label generation: ◆ To guide students to generate a Nutrition Facts label for their printed food	15 mins	◆ PowerPoint slides ◆ Notes
(5) Debriefing: ◆ To comment on the printed food made by students, whether the food is suitable for an infant or elderly ◆ To review the knowledge covered in all units	15 mins	◆ PowerPoint slides ◆ Notes
Total	**120 mins**	

2.4.4 Assessment (if appropriate)

- Students' knowledge of the working principle of 3D food printing and current applications of it will be assessed through polling and multiple-choice questions
- Students' knowledge of and experience in operating a 3D food printer will be assessed through the laboratory session
- Students' knowledge of the basic food and nutrition for an infant or elderly will be assessed through the worksheet
- 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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