THE CHINESE UNIVERSITY OF HONG KONG

Micro-Module Courseware Development Grant

Scheme 1: Basic Scheme

Final Report (2017-18) (Additional Call)

Report due 31 October 2018
Please return by email to The Ad hoc Committee on Planning of eLearning Infrastructure mmcd@cuhk.edu.hk

PART I

Project title: Development of VR/AR enhanced micro-modules for cell biology
Principal supervisor: Ngai Hung-Kui
Co-supervisor(s): N.A.
Department / Unit: School of Life Sciences
Project duration: From March 2018 to October 2018
Date report submitted: Oct 31, 2018

1. Project objectives

This project aims to develop a set of e-learning modules on cellular metabolism and to motivate students' learning using the latest virtual reality (VR) and augmented reality (AR) technologies. The project has been carried out smoothly and all objectives have been completed according to the schedule. There is no major amendment to the project objectives and so all the learning modules have been delivered on time.

2. Process, outcomes or deliverables

Three modules were developed in this project. Two modules, entitled "ATP synthase" & "Metabolites & hormones", were incorporated with AR technology in the e-learning materials. One module, entitled "Carnitine Deficiency and Metabolic Control" was incorporated with VR technology. Together with the existing VR/AR modules, these three newly developed modules provided an essential part of the e-learning materials for the teaching of energy metabolism in biochemistry curriculum. The nature of deliverables and the timeline remain unchanged. Depending on the class-size and learners' diversity, the e-learning modules were delivered with minor adjustment on the scope and structure of subject contents. The learning modules were adopted in different lecture courses, tutorials as well as laboratory training sessions. The details of the learning modules were described below.

Augmented Reality (AR) Modules – ATP synthase; Metabolites and hormones

(i) ***ATP synthase*** – This module aims to demonstrate the structure and mechanism of ATP synthesis using a mobile App entitled "ATP synthase [AR]". The mobile App was

developed with the technical support of ITSC (Mr. Ray Lee). The learning materials were made available for free download via various e-platforms including Google Play Store, Apple Store and CUHK Blackboard system. [Figure 1]

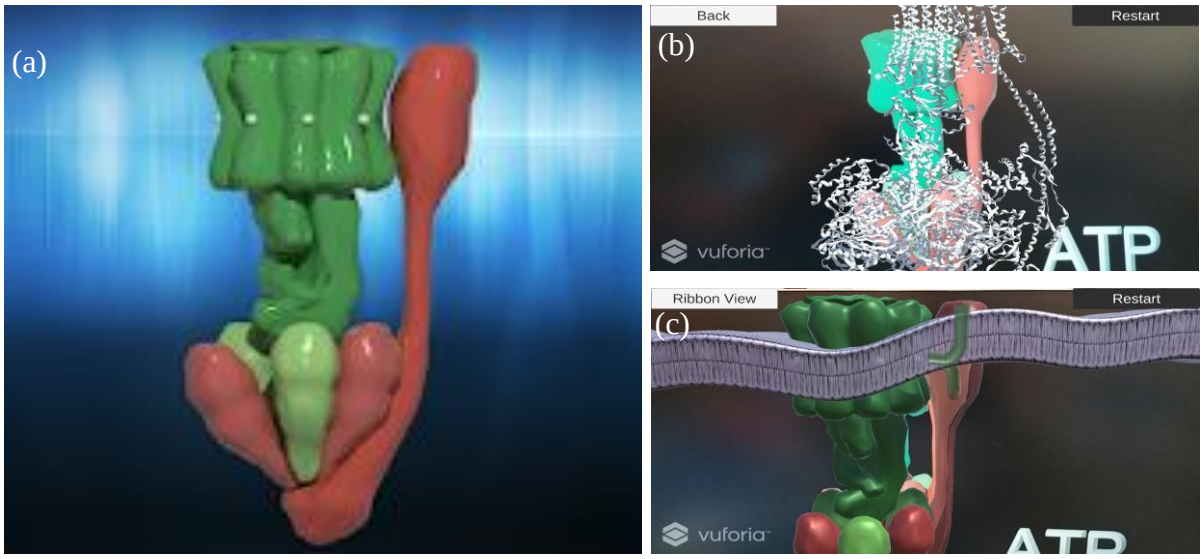

Figure 1 Snap shots of the control panel of the mobile App *"ATP synthase [AR]"*
(a) The logo of the mobile App. (b) Ribbon view of the molecule. (c) Close-up image of the molecular structure. The mobile App can be downloaded in the following website.
Website - *https://play.google.com/store/apps/details?id=hk.edu.cuhk.sls.atp*

As the implementation and use of the AR e-materials demand some technical instructions, a website was also especially designed to guide users through the installation and use of the mobile app. The website also provides the long-in credentials and graphic objects to elicit the 3-D animations from users' mobile cell phone. [Figure 2]

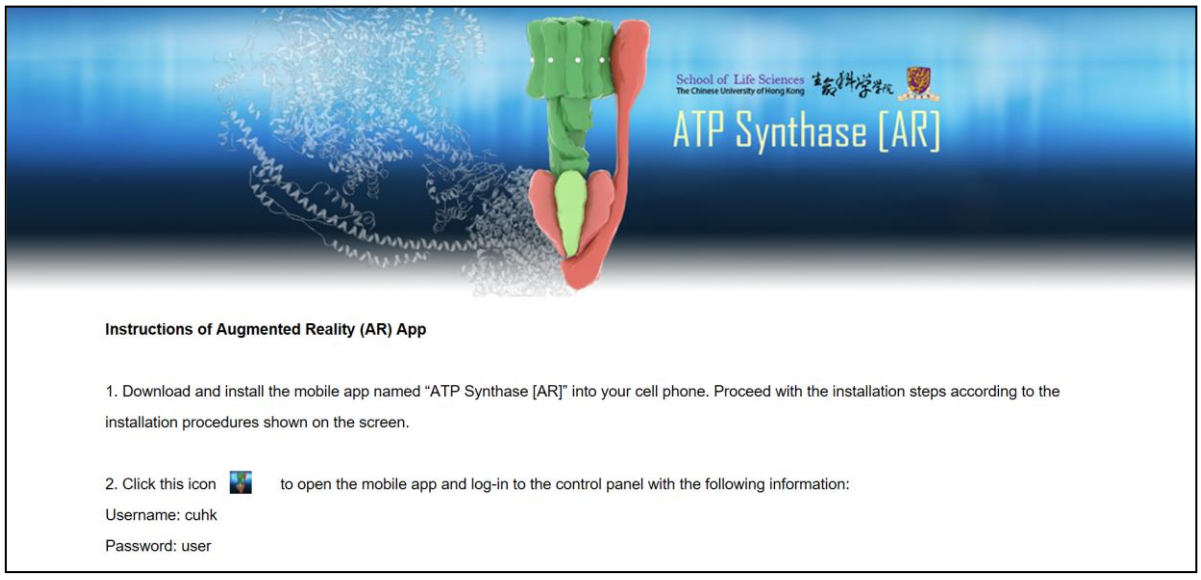

Figure 2 Snapshot of the instruction website of mobile app "ATP Synthase [AR]"
The long-in page can be freely accessed by users. *Website:* *http://137.189.27.142/atp/*

(ii) ***Metabolites and hormones*** – This mobile App aims to demonstrate the molecular structures of various glycolytic metabolites and the hormones for regulating the metabolism of carbohydrates. The mobile App was developed with the technical support of Mr. Eddie Kwok from the Centre for eLearning Innovation and Technology (ELITE). The e-learning materials were made available for free download in Google Play Store and CUHK Blackboard. The graphics of molecular structures were developed and incorporated into the *HP Reveal* online system under ELITE's channel (*elite.cuhk*). An instruction manual was designed to help users complete the account registration process and navigate the collection of biomolecules. [Figure 2]

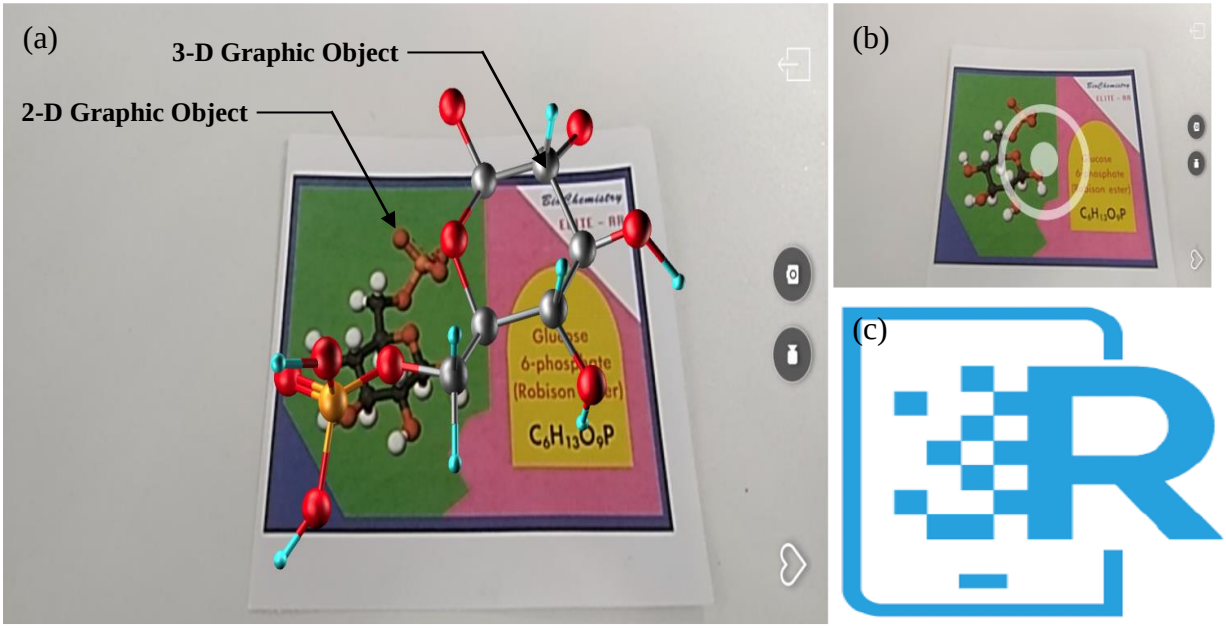

Figure 1 Snap shots of the control panel of the mobile App "Metabolites and hormones"
(a) A 3-D animation popped-up the mobile phone screen to demonstrate the molecular structure of Glucose 6-phosphate. (b) Scanning of the AR card with a mobile cell phone. (c) the logo of the HP reveal mobile app downloadable in the following website site.
Website - https://play.google.com/store/apps/details?id=com.aurasma.aurasma

As the graphic materials of this e-learning materials of this module was incorporated with the HP Reveal platform, a separate instruction manual was designed to guide users though the downloading, installation and use of the mobile app. [Figure 3]

Figure 3 Snapshot of the instruction manual of the mobile app in the HP Reveal platform.

Virtual Reality (VR) module - Carnitine Deficiency and Metabolic Control

This module aims to demonstrate the mechanism of carnitine facilitated transport across the mitochondrial membranes. The energy harnessed by oxidation of biological fuel such as fatty acids or carbohydrates is used to power the synthesis of ATP in the mitochondrial Electron Transport Chain (ETC). In this module, a mobile App entitled "Mitochon VR II" was developed in collaboration with ITSC (Mr. Ray Lee). The mobile App was made available in different e-platforms including Google Play Store, Apple Store and CUHK Blackboard system. After testing with users, minor bugs were found and later fixed in September 2018. [Figure 4]

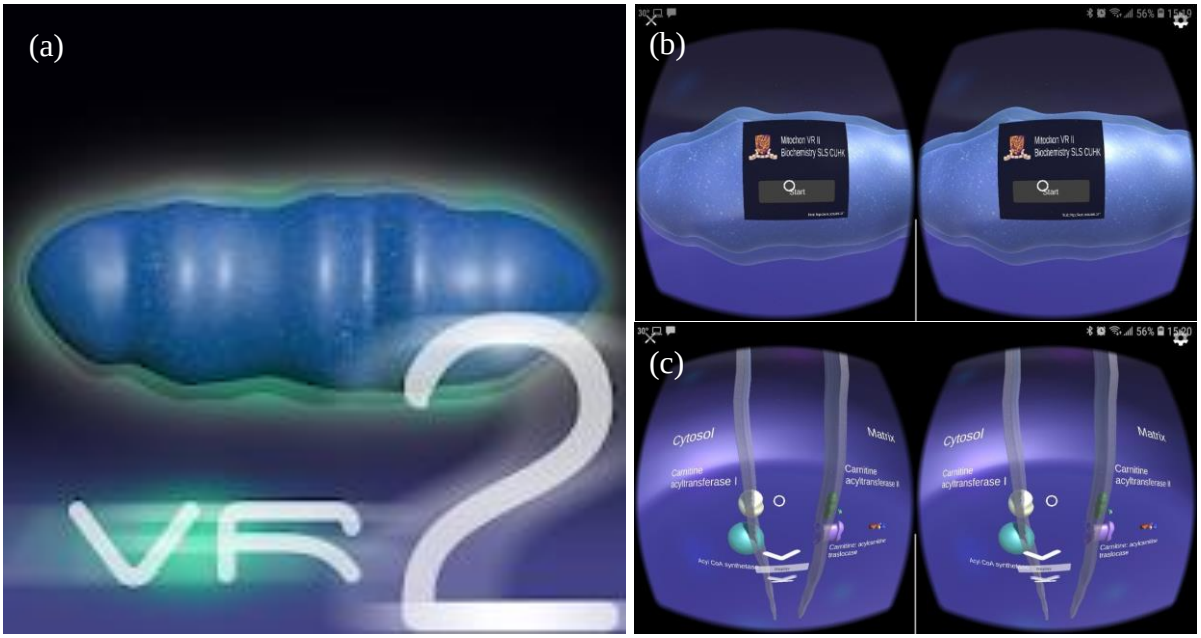

Figure 4 Snapshots of the control panel of the mobile app "Mitochon VR II"
(a) The logo of the mobile app. (b) Control panel showing the user dialog box in the entry page. (c) Immersive view of the 3-D intracellular compartment showing the trafficking of long-chain fatty acids across the two layers of mitochondrial membrane. The mobile app can be freely downloaded in the Google Play Store website as shown below.

Website: https://play.google.com/store/apps/details?id=com.itsc.mitochon

Implementation of the e-learning modules

The mobile apps and their pertaining learning materials can be accessed by users via different channels for free. The learning modules were also adopted by teachers in different biochemistry classes and used by students outside the classroom. The details are shown the following table. [Table 1]

Table 1 Implementation of the e-learning modules in biochemistry courses

Courses	Title of Modules (Contact Hour + Online Hour)		
	ATP synthase	Metabolites and hormones	Carnitine Deficiency and Metabolic Control
LSCI1000 Biochemistry of Life and Diseases	✓ (1 hr + 0.5 hr)	✓ (1 + 0.5 hr)	Nil
BCHE3080 Bioenergetics and Metabolism	✓ (1.5 hrs + 0.5 hr)	✓ (1.5 hrs + 0.5 hr)	✓ (0.5 hr + 0.5 hr)
UGEB2361 Great Discoveries in Life Sciences	✓ (0.5 hr + 0.5 hr)	✓ (0.5 hr + 0.5 hr)	Nil

3. Evaluation Plan

Evaluation for project improvement

The e-learning modules were used and evaluated by students and teacher users in the first, second and summer semesters of 2017 2018 and the first semester of 2018-2019 respectively. Opinions were collected in different stages to improve the accuracy of e-learning materials and increase the effectiveness of teaching and learning. Our existing evaluation schemes of the Biochemistry programme were adopted to help assess the project work and improve the effectiveness of the courses. The questionnaire survey and face-to-face discussion provide both quantitative and qualitative data on the learning materials developed in this project. These include the quality of computer graphics, opinions towards the *VR/AR* learning tools, compatibility of the multi-media materials with different mobile devices, satisfaction with the platform design, relevance of courseware to the course syllabus, motivation on the learning of science and the improvement of students' their learning.

According to the assessment of students' learning, feedbacks of users and the evaluation of courses, the objectives of the project are considered satisfactorily achieved. In particular, the CTE scores of LSCI1000 and BCHE3080 in 2017-2018 are higher than that of the departmental mean. A significant increase in the CTE scores of UGEB2361 has also been recorded between the two consecutive semesters of 2017-218. The data of the CTE scores are shown in [Table 2]

Table 2 Course & Teaching Evaluation Results of 2017-2019

Courses	Course & Teaching Evaluation Scores (Course Mean / Departmental Mean)			
	2017-2018			2018-2019
	Term 1	Tem 2	Summer	First
LSCI1000 Biochemistry of Life and Diseases	N.A	5.69 / 5.30	N.A	N.A
BCHE3080 Bioenergetics and Metabolism	5.17 / 4.92	N.A	N.A	N.A
UGEB2361 Great Discoveries in Life Sciences	N.A	5.00 / 5.22	5.56 / 5.32	*Pending*

4. Dissemination, diffusion and impact

Dissemination of Project

In-classroom

(i) LSCI1000 Biochemistry of Life and Diseases

(ii) BCHE3080 Bioenergetics and Metabolism

(iii) UGEB2361 Great Discoveries in Life Sciences

Conferences

(i) Poster presentation at the "CUHK Teaching and Learning Innovation Expo 2017" Title: Application of Virtual Reality (VR) Technology in the Teaching and Learning of Mitochondrial Functions.

(ii) Poster presentation at the Lilly Conference 2018: Designing Effective Teaching Title of poster: Implementation of Flipped Classroom in Undergraduate Biochemistry Courses, Maryland (USA).

Diffusion of Project

The learning modules were initially tested and adopted in LSCI1000, BCHE3080 and UGEB2361. These learning modules are also open to all life sciences students. The mobile apps can also be downloaded for free in Google Play Store and Apple Store.

Impact of project

In addition to the Biochemistry Programme, the two VR modules involving the cellular structures can be adopted in other courses provided by the Cell and Molecular Biology (CMB) Porgramme.

PART II

Financial data

Funds available: 82,250

Funds awarded from MMCDG $ 82,250

Funds secured from other sources $ 0
(please specify_____)

Total: $ 82,250

Expenditure:

Item	Budget as per application	Expenditure	Balance
Development of VR software by ITSC (Mitochondrial membrane transport)	49,000	49,000	0
Development of AR software by ELITE (Biomolecules modelling)	23,000	23,000	0
Student helper (project administration & coordination)	8,250	8,250	0
Surveys, logistics, stationeries & printing	2,000	2,000	9.09
Total:			9.09

PART III

Future Development

Because two different types of technologies (i.e. VR & AR) were adopted in this project, the implementation of e-learning modules have to be tailored in different courses according to learner's background and their propensity of learning habit. The effectiveness of learning is expected to be further elevated after several years of practical applications.

Key success factors / Difficulties

(i) Time management: A lot of time has to be reserved for coaching students in the use of the mobile apps.
(ii) Learning diversity: Special attention has to be paid to the address the diversified academic background of students. Motivating students in the e-learning module needs is some special skills.
(iii) Course planning: Integrating the e-learning modules into other traditional modules is to be designed holistically.
(iv) Course Evaluation: Not all students and co-teachers like the e-learning pedagogy. Risk of down grade in CTE scores shall not be neglected.

Technical support

ITSC (Mr. Ray Lee) and ELITE (Mr. Eddie Kwok) provides us a great deal of assistance in the project planning and multimedia production.

Suggestion

Funding scale is too small to develop more extensive or structured modules. It would be preferable to lifted to about $150,000 for a project.

PART IV

Information for public access

This project aims to develop a set of e-learning modules on cellular metabolism and to motivate students' learning using the latest virtual reality (VR) and augmented reality (AR) technologies. Animal cells require energy to perform all kinds of functions such as muscle contraction, heat generation and tissue repair. Inside the animal cells, there is a small structure called mitochondrion. It is a sub-cellular organelle which generates the required chemical energy from biological fuel such as fatty acids. Because the malfunction of mitochondria is related to many metabolic disorders, so the teaching of mitochondrial functions is included in many medical or life science courses. Interestingly, the sophisticated structure of mitochondria is known to be closely related to their functions. A good understanding of the internal structure of mitochondrion allows students to investigate the causes of different metabolic disorders and the mechanism of metabolic reactions. However, these subcellular structures and their molecular interactions are so complicated that students

often find it very difficult to conceptualize the biochemical principles involved in the process. Therefore, this project is designed to help students overcome the abovementioned learning difficulties and so to increase their learning effectiveness.

1. Keywords

(Most relevant) Keyword 1: Mitochondria

Keyword 2: Energy Metabolism

Keyword 3: Electron Transport Chain

Keyword 4: ATP

(Least relevant) Keyword 5: Carnitine

2. Summary

Table 1: Publicly accessible online resources (if any)
(a) **Project website:** http://137.189.27.142/atp/
(b) **Webpage(s):** *N.A.*
(c) **Tools / Services:** *N.A.*
(d) **Pedagogical Uses:** The following courses adopted the e-learning modules for flipped-classroom teaching (i) LSCI1000 Biochemistry of Life and Diseases (ii) BCHE3080 Bioenergetics and Metabolism (iii) UGEB2361 Great Discoveries in Life Sciences Three mobiles apps were provided for self-learning and in-class demonstration
(c) **Others (please specify):**

Table 2: Resources accessible to a target group of students (if any)
If resources (e.g. software) have been developed for a target group of students (e.g. in a course, in a department) to gain access through specific platforms (e.g. Blackboard,

facebook), please specify.

Course Code/ Target Students	**Term & Year of offering**	**Approximate No. of students**	**Platform**
LSCI1000 Biochemistry of Life and Diseases	2nd term of 17-18	30	Blackboard
BCHE3080 Bioenergetics and Metabolism	2nd term of 18-19	70	Blackboard
UGEB2361 Great Discoveries in Life Sciences	Summer term of 17-18	20	Blackboard

Table 3: Presentation (if any)	
Please classify each of the (oral/poster) presentations into one and only one of the following categories	**Number**
(a) In workshop/retreat within your unit (e.g. department, faculty)	-
(b) In workshop/retreat organized for CUHK teachers (e.g. CLEAR workshop, workshop organized by other CUHK units)	-
(c) In CUHK ExPo jointly organized by CLEAR and ITSC	1
(d) In any other event held in HK (e.g. UGC symposium, talks delivered to units of other institutions)	-
(e) In international conference	1
(f) Others (please specify)	-

Table 4: Publication (if any)	
Please classify each piece of publication into one and only one of the following categories	**Number**
(a) Project CD/DVD	-
(b) Project leaflet	-
(c) Project booklet	-
(d) A section/chapter in a booklet/ book distributed to a limited group of audience	-
(e) Conference proceeding	-
(f) A chapter in a book accessible internationally	-

(g) A paper in a referred journal	-
(h) Others (please specify) Mobile Apps	3

3. A one-page brief write up

Please provide a one-page brief write-up of no more than 500 words and a short video.

This project aims to develop a set of e-learning modules on cellular metabolism and to motivate students' learning using the latest virtual reality (VR) and augmented reality (AR) technologies. In summary, three e-learning modules on mitochondrial energy metabolism were produced in this project. These include the modules on "*ATP synthase", "Metabolites and hormones" and "Carnitine Deficiency and Metabolic Control".* Each module comprises a freely downloadable mobile app and a set of instruction materials. The mobile apps were designed with either AR or VR technology depending on the nature of the subject content. For example, VR technology was employed to provide an immersive environment for users to learn about the internal cellular structures and mechanisms. AR technology was adopted to provide an instant and interactive learning experience for users to understand the molecular structure of essential biomolecules. Individual e-learning modules were used in different undergraduate biochemistry courses (LSCI1000, BCHE3080 and UGEB2361) to facilitate the teaching and learning of abstract scientific concepts. The mobile apps could be used by teachers for in-class demonstration or used by students for self-learning at home. The questionnaire survey and face-to-face evaluation exercises showed that the e-learning modules have enhanced the effectiveness of students' learning and improve the CTE scores of the courses involved in this project. Based on our existing collection of e-learning materials, this project has further increased the quality of biochemistry teaching and learning in the School of Life sciences.