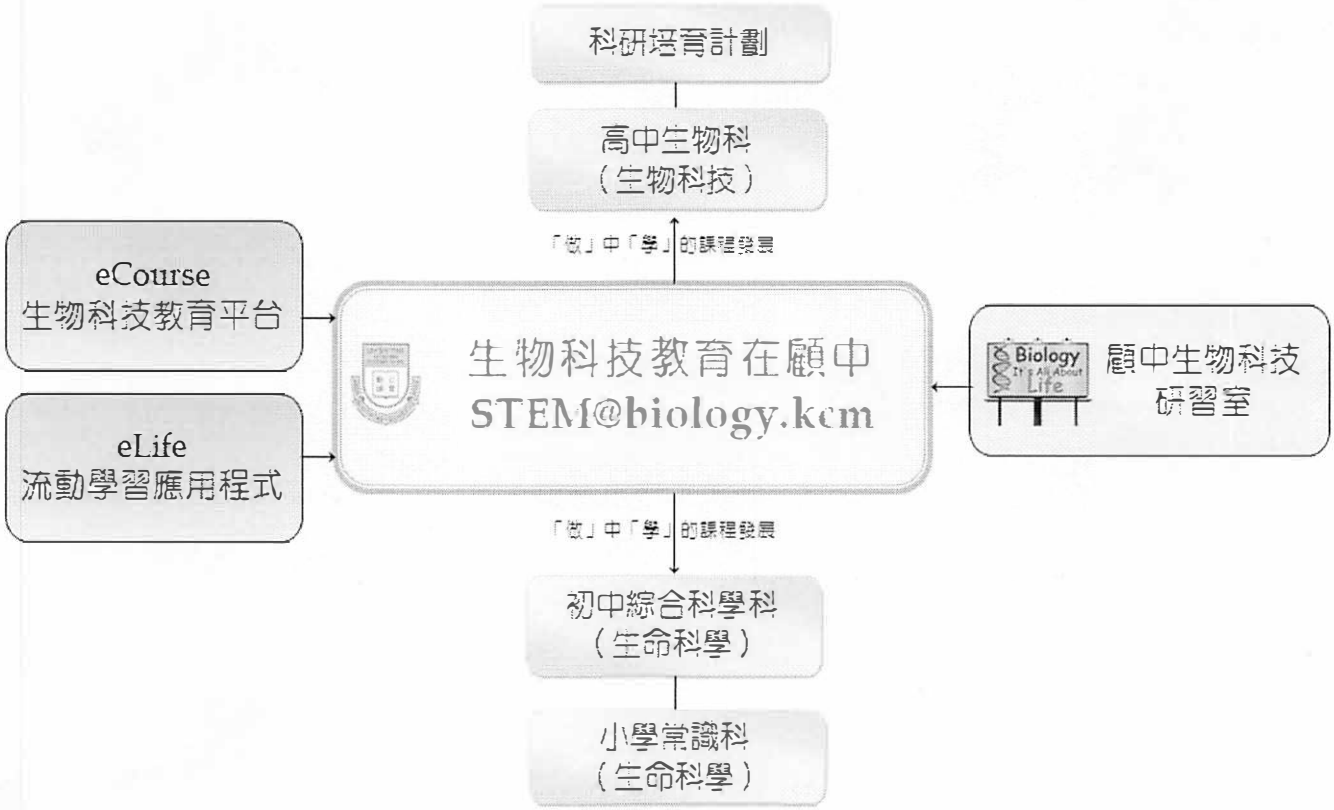
(一) 引言

《生物課程及評估指引》提出「以一個富彈性、連貫及多元化的高中課程配合，以便照顧學生的不同興趣、需要和能力」，本校「生物科」於初中設計遺傳學及生物工程的校本課程，並在高中進行生物工程的實驗和學習活動；更與　　成為合作夥伴，引入科研培育計劃，照顧學生的多樣性，提升學生各項共通能力，幫助學生建立積極的價值觀及學習態度，培養他們對生物學的興趣，提升解難能力，使其在面對高中生物科課程時更具信心。除了連貫性及多元化的課程革新外，教學範式須隨教育改革而轉變，以配合新的教育發展路向 - 發展創新科技。本校決意透過「生物科技教育在顧中 STEM @biology.kcm」，於初中綜合科學科及高中生物科推動生命科學及生物科技教育，希望透過這計劃，提升中學生對創新及科技的興趣。本校冀藉成立生物科技研習室，透過與大學的緊密協作，讓學生有進行科研的實際體驗，補充課堂理論教學的不足，帶動學生於生物科技的探究學習。另外，冀建立 eCourse 生物科技教育平台及 eLife 流動學習應用程式，推動科普教育及促進自主學習。希望這計劃能配合課程發展的新方向，讓學生在 STEM 教育的領域上能真正做到「學會學習」。



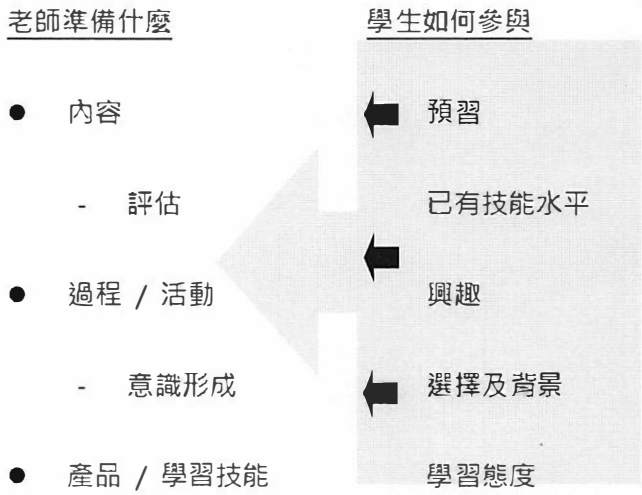
參與學校	角色	協作模式
嗇色園主辦可銘學校 嗇色園主辦可信學校	小學教師培訓	學與教資源增潤 (小六常識科)
樂善堂轄屬中學 李求恩紀念中學 香港四邑商工總會黃棣珊紀念中學 東華三院呂潤才中學	➢ 資源(教學套件、實驗活動及材料)借用 ➢ 顧中生物科技研習室借用	學與教資源增潤 (高中生物科) ➢ 凝膠電泳分離技術 ➢ 製作重組質粒及 DNA 指紋分析檢視
	高中學生培訓	科研培育計劃
	初中學生培訓	中醫中藥學習活動

(二) 計劃特色

1. 自主學習

本計劃中的自主學習套件按「自主學習」(Self-Directed Learning) 和「差異化教學 / 區分性教學」(Differentiated Instruction – Differentiated Content, Differentiated Process and Differentiated Product)[1] 的理念和取向設計。教師擔當的角色並不閒置，並非純粹的「放羊」自學，而是在適當的地方和時間「牧羊」- 自主學習。教師為前期作出大量的預備，例如 課程統整與實驗設計，並與大學科研工作者及校友，共同錄製生物科技影片，建立 eCourse 生物科技教育平台，學生觀看影片後就內容及實驗過程去『問與答』，在 eCourse 平台上互相討論、分析與日常生活有關的問題；能力較佳學生更可設計探究題目，運用生物科技研習室及大學實驗室的設備，實踐『做』中『學』，促進自主學習。另外，與資訊科技科合作，由學生編寫 eLife 流動學習應用程式，讓生命科學、生物科技及中藥栽種等知識得以運用及鞏固課程所學。以上過程中，教師擔任指導的角色，幫助學生學習、整合及檢視學生的構思和設計，引領著整個課程的進行，以免學生隨著喜好而作出偏離課程的設計。自主學習是集體活動，學習活動在學校所提供的體系(師資、設備、進度)中完成。故此本計劃可說是師生雙向的「導引式自主學習」。

學習者的關係



2. 學習社群

老師除了促進學生的自主學習外，透過 eCourse 生物科技教育平台，協助學生建立學習社群，令不同能力的學生從小組合作中得到學習的樂趣，並透過社群互助發展社交能力。學生可透過與教師、大學科研工作者及校友的對話、與同學討論、參與探究研習、運用生物科技研習室設備進行學習。學習社群的建立，可影響學生未來對生物科技的興趣和表現，同時亦可培養溝通技巧，對學生日後在科學及科技事業上的發展十分重要。

3. 照顧學生的多樣性

為照顧不同性向和能力的學生，本計劃提供多元化的活動，包括中藥栽種、中藥認證、管理及維護魚藥共生系統、編寫 eLife 流動學習應用程式、科研培育、參觀、講座、工作坊等，並成立生物科技研習室，協助提升學與教效能。也就是說，本計劃創造合適的探究學習環境，讓每位學生的潛能得以發揮，促進學生多思考、探究和尋找資料，並把它們整理和修改，促進「發現學習」(Discovery Learning)[2]，透過有關的知識、技能和態度，讓各學生在學習過程中發掘、探索，善用資料及應用知識，提升解難能力，培育有意義和主動學習的能力，因應不同的學習情景而得以鞏固、充實和提升。

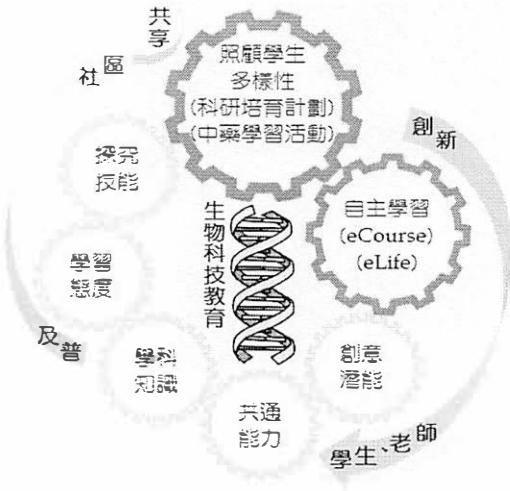
4. 生物科技教育在顧中 STEM@biology.kcm 與課程的開發、調適和增潤的關係

透過中央和校本課程的開發、調適和增潤，以連貫性、推動科普教育的課程（包括教師指引、學生工作紙、學習影片、實驗活動、評估習作和延續學習活動），讓初中學生無論於高中是否選修理科，均能體現有關生命科學的現象和理論，並以科學智慧和素養，尊重自己與他人的生命。

級別		中一	中二	中三	中四	中五
科目		綜合科學科（生命科學）		生物科（生物科技）		
課程發展處科學教育組的有關課程		科學(中一至中三) 課程架構 2016 （暫定稿）# 單元四 細胞、人類生殖與遺傳 (可參考附件一)	科學(中一至中三) 課程架構 2016 （暫定稿）# 單元七 生物與空氣	科學(中一至中三)課程架構 2016（暫定稿）# 單元十二 健康的身體	生物課程及評估指引 (中四至中六) 2007 必修部分 II 遺傳與進化 必修部分 III 生物與環境 必修部分 IV 健康與疾病	
		# 學校可於 2017/18 學年進行試教。更新課程將於 2018/19 學年實施				
校本課程的開發、調適和增潤 ＊做中學的課程發展＊	知識方面	1. 認識DNA結構（鹼基 ATCG、雙螺旋構造、鹼基配對)及其發現的歷史 2. 認識DNA、染色體和基因的關係 3. 認識性染色體在人類決定性別的角色 4. 認識人類性狀遺傳	1. 認識植物性狀遺傳 2. 認識基因改造食物 3. 了解生物工程對社會的影響	1. 認識人類基因組計劃及其含意 2. 認識人類遺傳病及檢測 3. 討論健康生活方式(例如中藥養生)	1. 認識凝膠電泳的分離技術和應用 2. 認識重組DNA技術 3. 認識組織培養	1. 掌握中一至中四已有知識並將其聯繫 2. 認識校本評核的要求 3. 認識生態系的運作
	技能方面	1. 製作 DNA 平面模型 (1 課節) 2. 製作 DNA 立體模型，培養具科學化和創意的思維思考 (1 課節) 3. 製作遺傳性狀樹，以分析一個性狀在家庭中的遺傳 (1 課節) 4. 運用立體顯微鏡分辨秀麗線蟲的基本遺傳 (1 課節)	1. 提取DNA，親身感受遺傳物質 (2 課節) 2. 分辨基因改造食物 (1 課節) 3. 檢視及研究玉蜀黍穗粒顏色的單基因遺傳 (1 課節)	1. 學生栽種中藥，管理及維護顧中藥園(中藥的產量) 2. 學生編寫 eLife 流動學習應用程式 (例如 人類性狀遺傳、DNA 編碼及解碼、人類遺傳病、中藥知識及應用等) (8 課節)	1. 進行凝膠電泳分離技術 (2 課節) 2. 製作重組質粒及以DNA指紋分析進行檢視 (4 課節) 3. 進行組織培養及藥物檢測 4. 進行中藥認證(中藥的質量) 5. 進行科研培育計劃	1. 進行校本評核實驗 (8 課節) 2. 學生運用 eCourse 生物科技教育平台及顧中生物科技研習室的設備，進行有關分子遺傳學的探究研習(例如檢測基因改造食物、秀麗線蟲突變遺傳、rtPCR 等) 3. 學生管理維護魚藥共生系統
	態度方面	1. 欣賞不同科學家對遺傳學的貢獻 2. 對生命起源產生好奇心 3. 欣賞 DNA 和染色體在生命中的角色	1. 體會社會需求能促使科技的進步 2. 體會遺傳學知識在社會上的應用及其對社會、道德倫理和經濟的含意	1. 體會從人類基因組計劃取得數據的貢獻和局限 2. 體會人類基因組計劃有賴科學家共同努力 3. 體會現代科技進步和發現如何對疾病檢定、治療、預防和控制作出貢獻	1. 體會遺傳學的迅速發展，從傳統育種的實驗至分子生物學的實驗和分析 2. 體會科學與科技對人們了解生活型的複雜性及遺傳學方面扮演的角色	1. 體會生物學知識和理論是透過觀察、假說、實驗和分析而產生 2. 解釋生物工程知識如何促進新科技的發展及新科技如何帶動人們對遺傳的了解 3. 體會生態系不斷轉變的本質

(三) 本校優勢

1. 創新與普及



於創新方面，就課程發展議會 2015《推動 STEM 教育發揮創意潛能概覽》[3]所述，讓學生充份發揮創意潛能，學生需要創新科技以回應時代需求 - 由課本主導及以老師為中心的傳統教學模式，轉向以學生為中心的自主學習模式，本校以建立 eCourse 生物科技教育平台、eLife 流動學習應用程式，及成立顧中生物科技研習室，推動生命科學和生物科技教育。在課程方面，我校的初中綜合科學科已自主開發探究研習課程及與設計科技學會舉辦探究研習比賽的經驗，積極發展學生的科學過程技能；中三級生物科亦已自主開發校本課程及高中生物科已開展生物工程的實驗活動，積極嘗試加入生物科技教學的元素以促進學與教。隨著 STEM 及創新科技教育的推動，透過「生物科技教育在顧中 STEM@biology.kcm」進一步整合及優化本校生命科學和生物科技的教育。

於普及方面，本校的優勢在於與社區夥伴協作的經驗。本校與兩所大學 -
，於 2015-16 學年開展科研培育計劃及中醫中藥學習活動，成為學生學習生物科技和中醫中藥的合作夥伴（詳情可參考附件二及三），這意味著 eCourse 生物科技教育平台的推動、顧中生物科技研習室的運用、管理及維護將獲得優化與提升。另外，本校與非政府組織 - ，合作栽種中藥；下學年將與 所合作，透過定期舉辦課程及興趣班，將中醫中藥知識、養生之道，以及「健康老齡化」加以推廣。此外，藉開放顧中生物科技研習室或借用儀器予其他中、小學(樂善堂轄屬中學、李求恩紀念中學、香港四邑商工總會黃棣珊紀念中學、東華三院呂潤才中學、嗇色園主辦可銘學校及嗇色園主辦可信學校)，讓生物科技教育得到持續性的普及，實踐「STEM for ALL」。

除此以外，本校早於 2013-14 學年已與嗇色園主辦可銘學校及可信學校合作，參與紅外線遙控開關電路及產品創作工作坊及比賽；更希望藉著本計劃，將初中綜合科學科與高小常識科課程連繫，開發課程、增潤學與教的資源，更讓中、小學生共同設計及製作課程相關的 eLife 流動學習應用程式，更有效推動生命科學及生物科技教育。

2. 推行生物科技課程及 STEM 教育活動的經驗

(四) 團隊的詳情

職位	擔當角色	職責	
教師	項目統籌員	作為行政人員，處理課程開發、試教及安排和帶領活動	
		a	統整校本初中綜合科學科及高中生物科課程
		b	開發初中生命科學課程及釐定相關的實驗設計、活動
		c	調適中三級生物科遺傳學及生物工程的校本課程
		d	增潤高中生物科課程、校本評核實驗及魚藥共生系統
		e	籌劃及管理顧中生物科技研習室
		f	籌備及建立 eCourse 生物科技教育平台
		g	籌備及建立 eLife 流動學習應用程式
		h	設計、安排及帶領科研培育計劃
		i	設計、安排及帶領中藥栽種、中藥認證、參觀、講座、工作坊等所有活動
		j	試教並評估教材、教學方法、實驗設計及成效
		k	負責項目的跟進
		l	研究及推展有關計劃
		m	舉辦教師持續專業發展的活動
		n	推廣相關教材、分享教學經驗與普及顧中生物科技研習室的使用
資歷(過往經驗)：	a	統籌初中綜合科學科探究研習比賽；	
	b	設計中三級生物科遺傳學及生物工程的校本課程；	
	c	設計高中生物科生物工程的實驗活動及有關 STEM 教育活動；	
	d	設計科研培育計劃，與[redacted]合作，安排學習活動；	
	e	栽種中藥，與[redacted]合作，安排學習活動；	
	f	參與教育局舉辦的組織培養工作坊，並使用提供的椰菜花組織培養教材套，進行生物工程的實驗活動；	
	g	建立魚藥共生系統及有關 STEM 教育活動；	
	h	參與香港電腦教育學會舉辦「學習如此多紛 2016 - IT 學與教」電子套件製作比賽；	
項目助理（一位全職）（一位兼職）	項目成員 (僱用時間為 2018 年 4 月至 2020 年 2 月) (I) 2018 年 4 月至 2018 年 9 月 (II) 2018 年 10 月	作為執行人員，協助項目統籌員推行、策劃計劃中的行政工作、帶領活動及評估成效	
		(I)	前期籌備(開發、整理及設計教材)：
		a	協助項目統籌員開發中一及中二級生命科學課程及釐定相關的實驗設計
		b	協助項目統籌員調適中三級生物科遺傳學及生物工程的校本課程
		c	籌備顧中生物科技研習室及購買實驗儀器、設備
		e	試行科研實驗、撰寫實驗步驟及實驗儀器的使用細則
		f	籌備及建立 eCourse 生物科技教育平台
		g	與大學科研工作者及校友共同錄製生物科技影片
		h	籌備及建立 eLife 流動學習應用程式
		(II)	第二時段(設計教材、帶領學習活動及評估)：
		a	協助項目統籌員增潤高中生物科課程、校本評核實驗及魚藥共生系統
		b	設計、安排及帶領科研培育計劃
		c	設計、安排及帶領中藥栽種、中藥認證、參觀、講座、工作坊等活動
		d	評估教材、教學方法、實驗設計及成效
		e	推廣相關教材與普及顧中生物科技研習室的使用

	至 2019 年 9 月 (III) 2019 年 10月 至 2020 年 2 月	(III)	第三時段(後期推廣及評估)：
		a	評估教材、教學方法、實驗設計及成效
		b	製作光碟及教材套
		c	推廣相關教材與普及顧中生物科技研習室的使用
資歷：	a	主修生物學 / 生物化學或生物科技，有進行生物科技或生物工程等科研實驗的經驗；	
	b	懂得建立和管理教育平台及編寫流動學習應用程式，並在當中製作相關電子學習資源及錄製生物科技影片；	
教師 (一位)	項目成員 (僱用時間為 2018 年 9 月至 2019 年 8 月)	作為執行人員，協助項目統籌員進行課程開發、試教、帶領活動及評估成效	
		a	試教、評估並修訂初中生命科學課程及相關的實驗、活動
		b	試教、評估並修訂中三級生物科遺傳學及生物工程的校本課程
		c	試行、評估並修訂高中生物科課程、校本評核實驗及魚藥共生系統
		d	運用及推廣顧中生物科技研習室
		e	製作 eCourse 生物科技教育平台的生物科技影片
		f	試行、評估並修訂 eLife 流動學習應用程式
		g	設計、安排及帶領科研培育計劃
		h	設計、安排及帶領中藥栽種、中藥認證、參觀、講座、工作坊等活動
		i	試教並評估教材、教學方法、實驗設計及成效
		j	推廣相關教材、分享教學經驗與普及顧中生物科技研習室的使用
資歷：	a	主修生物學 / 生物化學或生物科技，有初中綜合科學科及高中生物科的教學經驗；	
	b	有進行生物科技或生物工程等科研實驗的經驗；	

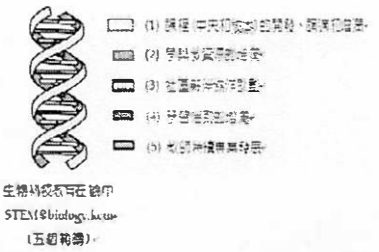
(五) 對優質教育基金的期盼

本校生物科於 2015-16 學年已局部推行上述的計劃和活動，然而，由於資源有限，只能製作少量教材及進行有限的實驗。若要作出大規模的革新，讓本校及其他同工獲益，須騰出教師的部份課擔。故本計劃期望能獲得優質教育基金的撥款，落實推行計劃，造就莘莘學子，方便前線教師施行計劃，提升學與教的質素。本校期望統整初中綜合科學科及高中生物科，以推動生命科學及生物科技教育。除統整校本課程外，亦會作出範式轉移，運用 eCourse 生物科技教育平台、eLife 流動學習應用程式，推動科普教育及促進自主學習。此外，學生藉運用顧中生物科技研習室進行探究學習，讓學生能主動參與學與教，真正成為創新科技人。

(六) 目的與目標

1. 整體目的

在本校現有初中生物科遺傳學及生物工程的課程基礎上，統整校本初中綜合科學科及高中生物科課程，著重對生命科學和生物科技的連貫性教育，透過生物科課程與創新科技的結合，為課程注入新教育發展路向的科普科研內容。另外，透過與大學科研工作者合作，啟發學生發展科學探究技能，體現生命科學，培養科學智慧和素養，提升解難能力，推動科學的普及，鼓勵他們將來投身科研工作，裝備他們以應對不斷變化的社會需求。創新科技是現今發展 STEM 教育的大趨勢，強調理論與實踐之間的相互作用和關係。故此，本計劃與大學科研工作者合作定能深化科普科研的教學，而在校建立生物科技研習室可讓創新科技得到持續的發展。



生物科技教育在顧中
STEM@biology.kcm
(五個特徵)

2. 本計劃期望

(1) 課程(中央和校本)的開發、調適和增潤

1.1 提升生物科概念理論和應用學習之間的平衡，透過科普科研教學，將科學、科技、工程和數學的學習連繫，幫助學生了解生物學知識的應用(例如 製作 DNA 模型、凝膠電泳分離技術、製作重組質粒、進行組織培養及藥物檢測等)，並藉建立 eCourse 生物科技教育平台及顧中生物科技研習室，推動生命科學和生物科技教育，促進自主學習及達致『做』中『學』的課程發展 (詳情可參考第 3 頁 生物科技教育在顧中 STEM@biology.kcm 與課程的開發、調適和增潤的關係)

1.2 設計初中綜合科學科生命科學的校本科普教育課程，從小培育學生對遺傳學的興趣及科學過程技能；並與資訊科技科合作，由學生編寫 eLife 流動學習應用程式(例如 人類性狀遺傳、DNA 編碼及解碼、人類遺傳病、中藥知識及應用等)，建立學生自主學習和終身學習的能力，促進學生了解當今生物學的各種議題，提升學生學習的主動性

1.3 透過中三生物科生物科技的校本課程，銜接初中與高中課程內容，為學生提供多元化選擇，並由學生栽種中藥，管理及維護(中藥的產量)，照顧學生的不同興趣和需要

1.4 高中生物科遺傳學及生物工程的必修課程內，引入科研內容及科研培育計劃，進行有關分子遺傳學的探究研習(例如 檢測基因改造食物、秀麗線蟲突變遺傳、rtPCR 等)，以期擴闊學生的視野，提升解難能力，讓學生對一些課題作深入的探究研習及進行校本評核實驗，為日後在相關範疇繼續學習作好準備

1.5 透過生物科課程與科普科研教學的結合，把學生在初中學到的科學探究、顯微鏡的觀察技能等連貫起來(例如 運用立體顯微鏡分辨秀麗線蟲的基本遺傳、中藥認證等)，組成縱向的學習經歷，加強與高中生物科課程的銜接及提升學生進行校本評核能力

(2) 學與教資源的增潤

2.1 與[redacted]繼續合作，推行科研培育計劃；中四級生物科學生於中學日常課堂學習生物科技理論(細胞週期和分裂、基礎遺傳學、分子遺傳學、及應用遺傳學)後，根據評核及透過面試，由大學甄選三至五名學生，於大學實驗室進行生物科技實驗及探究，製作重組質粒及以 DNA 指紋分析進行檢視，計劃中讓學生學習生物科技的前沿技術

2.2 與[redacted]，成立顧中生物科技研習室，為學生提供一個專業的科研環境以進行實驗；並藉着與大學的緊密協作，讓顧中生物科技研習室的運用、管理及維護得以持續發展、優化與提升；同時，本校學生可運用顧中生物科技研習室，將科研培育計劃中，例如從製作重組質粒而獲得的經驗及資源，分享至轄屬中學或其他中學，讓更多學生能透過對生物科技前沿技術的體驗，帶動生物科技的探究學習，提升學生學習生物科技的興趣及科學素質

2.3 與[redacted]繼續合作，推行中藥認證學習活動(中藥的質量)；並舉辦中醫中藥知識講座及工作坊，增潤生物科遺傳學及生物工程的必修課程內容，並為學生提供多元化選擇，照顧學生的不同興趣和需要

2.4 與[redacted]成為合作夥伴，為學生學習中醫中藥及有關「健康老齡化」的科研探究提供一個學習環境; 同時，本校學生可將中藥認證學習活動，分享及推廣至中小學，提升學生學習中醫中藥的興趣及科學素質

2.5 運用栽種的中藥，結合魚類飼養，由學生管理及維護魚藥共生的生態學應用系統，從而提升學生的解難能力。中五級生物科學生於課堂學習生態學理論後，分為四組(魚類飼養、中藥栽種、非生物因素、拍照記錄)，建構及優化系統；同時，學生應用飼養的斑馬魚及栽種的中藥，結合顧中生物科技研習室的儀器和設備，進行遺傳學及生物工程的探究研習，增潤生物科必修課程內容，提升學生學習生物科技及中醫中藥的興趣

2.6 與 合作，與大學科研工作者及校友共同錄製生物科技影片，建立及推動 eCourse 生物科技教育平台，學生觀看影片後就內容及實驗過程去『問與答』，互相討論、分析；更可設計探究題目，運用顧中生物科技研習室的儀器和設備，實踐『做』中『學』。過程中大學科研工作者、校友、教師及實驗室技術員擔任指導的角色，整合及檢視學生的構思和探究設計，引領自主學習課程的進行

2.7 與資訊科技科合作，建立 eLife 流動學習應用程式，讓學生學習生命科學及生物科技的知識後，編寫 eLife 流動學習應用程式，例如 人類性狀遺傳、DNA 編碼及解碼、人類遺傳病、中藥知識及應用等，讓生命科學、生物科技及中藥栽種等知識得以運用及鞏固課程所學

2.8 運用 eCourse 生物科技教育平台、及顧中生物科技研習室的儀器和設備，進行校本評核實驗或有關分子遺傳學的探究研習(例如 檢測基因改造食物、秀麗線蟲突變遺傳、rtPCR 等)，讓學生在探究思考期間，了解生物學知識是透過觀察、假說、實驗和分析而產生，而理論與實踐之間有著不可分割的關聯；同時，透過閱讀一系列生物學的文獻，增強學生的科學素養、閱讀與思考能力，對生物學知識理論有更多的了解與融合

2.9 與 講師合作，與大專學生進行課程相關的生物科技探究實驗

2.10 與嗇色園主辦可銘學校常識科 繼續合作，將初中綜合科學科與高小常識科課程連繫，開發課程、增潤學與教的資源，更讓中、小學生共同設計及製作課程相關的 eLife 流動學習應用程式，更有效全面地推動生命科學及生物科技教育

2.11 透過資源開放，其他中、小學於星期六或假期可使用顧中生物科技研習室或借用儀器；透過定期舉辦課程或興趣班(例如 製作 DNA 模型、檢測基因改造食物、藥物檢測及中藥認證學習活動等)，讓生命科學和生物科技的教育持續普及

(3) 社區夥伴協作計劃

3.1 與 繼續合作，在校內栽種更多中藥；同時，結合顧中生物科技研習室的儀器和設備，進行探究研習(中藥的質量)，讓學生能親身體驗栽種樂趣，訓練責任感、關愛、積極態度外，也可鼓勵他們將來繼續學習中醫中藥或投身科研工作

3.2 與 合作，舉辦課程及興趣班(例如 中醫中藥知識、養生之道、「健康老齡化」等)

3.3 與 繼續合作，在校內栽種更多中藥，並透過舉辦課程及興趣班(例如 中醫中藥知識、養生之道、「健康老齡化」等)；同時，將栽種的中藥(中藥的產量)及認證學習活動(中藥的質量)，推廣至其他中、小學

(4) 學習活動的增潤

4.1 舉辦與課程相關參觀活動(例如 實驗室、 學院、 中醫診所、姊妹學校等)，從知識建立到欣賞生物知識應用的奧妙，提升學習態度和素質

4.2 設計多元體驗活動(例如 魚藥共生系統製作、管理及維護等)，並應用飼養的斑馬魚及栽種的中藥，結合顧中生物科技研習室的儀器和設備進行探究研習，加強學生對相關課程的體會，提升學習效能；學生參與活動後，透過定期展覽和學校網頁的分享，提升本校學習生物科技的氣氛

(5) 教師持續專業發展

5.1 透過其他科任教師(例如 資訊科技科等)協作參與，提升學與教效能

5.2 透過由 及 的科研工作者、校友，舉辦課程或興趣班，將科普科研教學及顧中生物科技研習室儀器和設備的運用，指導各理科科任教師及實驗室技術員，並推展至其他科目及學校，讓生物科技學習能持續推行與發展，暫例如下：

培訓內容	第一次舉行日期	培訓項目
DNA 結構及遺傳特徵	2018 年 11 月	小學教師
生物科技教育工作坊(一)	2018 年 9 月	本校理科教師
生物科技教育工作坊(二)	2018 年 11 月	本校理科教師

5.3 透過九龍樂善堂教育聯網的學與教資源平台及樂善堂品質圈計劃分享教學經驗及教材

(七) 各持分者在計劃中擔任的角色

教師	學生	學校
➢ 課程促進者	➢ 透過課前已上載 eCourse 生物科技教育平台的指引及資料預備內容	➢ 提供 eCourse 生物科技教育平台
➢ 提供學習指引及資料（列明該課節學與教的內容：如何尋找及運用相關的影片）	➢ 透過自行上網補充生物科技學與教的內容，進行自主學習	➢ 提供顧中生物科技研習室合適的儀器和設備，供學生使用
➢ 引導學生自主學習	➢ 透過與教師、大學科研工作者及校友的對話、與同學的討論，參與探究研習、製作 eLife 流動學習應用程式、運用顧中生物科技研習室的儀器和設備進行學習，過程中從態度、技能及知識的討論而獲得改善建議	➢ 安排大學科研工作者及校友協作、舉辦課程或興趣班，優化與提升生物科技的學習
➢ 參與學生討論，彼此共同建構知識		
➢ 整合學生所構思和設計的探究		➢ 強化社區夥伴的協作與普及
➢ 安排與生命科學和生物科技相關活動		
➢ 將學生所學融入評估當中（例：測考、校本評核等）		

(八) 推行方案、受惠人數及與目標的關係

整個計劃及活動設計共二十三個月，分為三個時段：
第一時段是開發、整理及設計教材
第二時段繼續設計教材並作試教、進行學習活動及評估當中成效
第三時段作後期評估及推廣

以下是計劃內擬舉辦活動的時間表及細則：
* 內容會因應課程需要或學生需要有所變更或調適

範疇	項目	內容 *	工作安排	完成日期	對象	受惠人數	備註
籌備	顧中生物科技研習室	1. 規劃及建立	設定標書內容	4/2018	承建商	/	/
			邀請報價	4/2018			
			審視報價書	5/2018			
			決定承建商	5/2018			
			監察建立研習室進度	6-9/2018			
		2. 購買儀器、設備及物資	邀請報價	5/2018	相關公司		
			審視報價書	6/2018			
			購買儀器、設備及物資	7-9/2108			
	溝通會議	1. 與大學會議	溝通協作細節	4/2018	大學		
		2. 與中學會議		4/2018	中學		
		3. 與小學會議		5/2018	小學		
		4. 與社區伙伴會議		5/2018	社區伙伴		
〔1〕課程（中央和校本）的開發、調適和增潤	初中綜合科學科（生命科學）	1. 製作 DNA 平面及立體模型	設計工作紙	5-6/2018	中一級學生	130(x8)	➢ 有關教學套件的理念和取向設計請參照第 3 頁 4. 生物科技教育在顧中 STEM@biology.kcm 與課程的開發、調適和增潤的關係 ➢ 實驗活動會於顧中生物科技研習室準備及進行 ➢ 資源(教學套件、實驗活動及材料)開放予參與本計劃的八間中學、兩間小學及其他中小學 ➢ 成功技術後參加比賽(例
			設計模型材料	5-6/2018			
			分發工作紙、模型材料	12/2018			
			收回優秀作品	12/2018			
		2. 運用立體顯微鏡分辨秀麗線蟲的基本遺傳	設計課程及工作紙	9-10/2018		130(x8)	
			分辨秀麗線蟲的基本遺傳	12/2018			
		3. 提取 DNA	設計課程及工作紙	5-6/2018	中二級學生	130(x8)	
			提取 DNA	12/2018			
	中三生物科（生物科技）	1. 栽種及管理中藥(中藥的產量)	設計分工表	7-8/2018	中三級學生	20	
			栽種及管理中藥	10/2018			
		2. 編寫 eLife 流動學習應用程式	設計課程	7-8/2018		130(x8)	
			學生編寫程式	10/2018			
	高中生物科（生物科技）	1. 凝膠電泳的分離技術	設計課程及工作紙	8-10/2018	中四及中五級學生	50(x8)	
			學習分離技術	3/2019			
		2. 製作重組質粒及 DNA 指紋分析檢視	設計課程及工作紙	8-10/2018		50(x8)	
			製作重組質粒及檢視	3/2019			
		3. 進行組織培養	設計課程及工作紙	8-10/2018		20(x8)	
			進行組織培養	3/2019			
		4. 藥物檢測	設計課程及工作紙	8-10/2018		20(x8)	
			進行藥物檢測	3/2019			

〔2〕學與教資源的增潤	（科研培育計劃）	1. 科研培育計劃	設計課程 甄選學生參加 進行科研實驗	3/2019 4/2019 5/2019	中四級學生	2(x8)	➢ 有關活動於顧中生物科技研習室進行 ➢ 資源(教學套件、實驗活動及材料)開放予參與本計劃的八間中學、兩間小學及其他中小學 ➢ 成功技術後參加比賽(
	(中醫中藥學習活動)	1. 中醫中藥學習活動	設計課程 甄選學生參加 進行學習活動	7-8/2018 10/2018 10/2018	中五級學生	10(x8)	
	香港浸會大學國際學院	1. 血型猜猜猜	設計課程 / 套件 進行學習活動	3/2019 4/2019	中四級學生	2(x8)	
		2. 益生菌好滋味	設計課程 / 套件 進行學習活動	3/2019 4/2019		2(x8)	
		3. 動植物蛋白質大比拼	設計課程 / 套件 進行學習活動	3/2019 4/2019		2(x8)	
	eCourse 生物科技教育平台 (共 20 輯教育短片)	1. DNA 結構齊填色	設計課程 中一級學生拍攝及製作短片 瀏覽教育短片及填色	5-6/2018 12/2018 12/2018	小六級學生、中一及中二級學生	20(x2)	➢ 由中一及中二級學生拍攝教育短片，並擔任六年級學生的小老師 ➢ 資源(教學套件、實驗活動及材料)開放予參與本計劃的兩間小學及其他小學
		2. DNA 模型製作	設計課程 中一級學生拍攝及製作短片 瀏覽教育短片及模型製作	5-6/2018 12/2018 12/2018		20(x2)	
		3. 提取 DNA	設計課程 中一級學生拍攝及製作短片 瀏覽教育短片及提取 DNA	5-6/2018 12/2018 12/2018		20(x2)	
		4. 凝膠電泳的分離技術	設計課程 大學生、校友拍製短片 瀏覽教育短片	8-10/2018 8-10/2018 3/2019	中四級學生、大學生、校友、教師、實驗室技術員	20(x8)	➢ 課前上載指引，學生進行自主學習 ➢ 學生透過與大學科研工作者、校友及教師討論，運用顧中生物科技研習室設備學習 ➢ 資源(教學套件、實驗活動及材料)開放予參與本計劃的八間中學及其他中學
		5. 製作重組質粒及 DNA 指紋分析檢視	設計課程 大學生、校友拍製短片 瀏覽教育短片	8-10/2018 8-10/2018 3/2019		20(x8)	
		6. 組織培養	設計課程 大學生、校友拍製短片 瀏覽教育短片	8-10/2018 8-10/2018 3/2019		20(x8)	
	eLife 流動學習應用程式	1. 齊來認識 DNA	設計課程 中三級學生編寫程式 使用程式學習	7-8/2018 10/2018 12/2018	小六級學生、中三級學生	2000	➢ 中三級學生編寫應用程式，並擔任工作坊的小老師 ➢ 資源(教學套件、實驗活動及材料)開放予參與本計劃的八間中學、兩間小學及其他中小學 ➢ 成功技術後參加比賽(
		2. 「遺傳特徵」對對碰	設計課程 中三級學生編寫程式 使用程式學習	7-8/2018 10/2018 12/2018		2000	
		3. 編寫「遺傳特徵」流動學習應用程式工作坊 (共 6 次)	設計課程 中三級學生擔任小老師 使用程式學習	7-8/2018 12/2018 12/2018		20	

	校本評核課業	1. 檢測基因改造食物	設計課業	8-10/2018	中五級學生	50(x8)	➢ 運用顧中生物科技研習室內適當儀器進行探究 ➢ 資源(教學套件、實驗活動及材料)開放予參與本計劃的八間中學及其他中學
			進行探究	4/2019			
			完成課業	5/2019			
		2. 探究秀麗線蟲突變遺傳	設計課業	8-10/2018		50(x8)	
			進行探究	4/2019			
			完成課業	5/2019			
〔3〕社區夥伴協作計劃		1. 中藥顯微鑒定(中藥的質量)	設計課程	7-8/2018	中小學生、全校教師	20(x8)	➢ 活動於顧中生物科技研習室進行 ➢ 資源開放予參與本計劃的八間中學及其他中學
			進行實驗	10/2018			
		2. 提取中藥 DNA	設計課程	7-8/2018		20(x8)	
			進行實驗	10/2018			
		3. 中藥認證和成份分析(中藥的質量)	設計課程	8-10/2018		20(x8)	
			進行實驗	4/2019			
		1. 食療講座	安排講座	11/2018		200	
		1. 栽種及管理中藥	建立及管理(中藥的產量)	10/2018		20	➢ 資源開放參與本計劃八間中學、兩間小學及其他中小學
		2. 「認識中藥」流動學習應用程式	設計課程	7-8/2018		2000	
			學生編寫程式	10/2018			
			使用程式學習	12/2018			
〔4〕學習活動的增潤	參觀活動	1.	參觀及交流 安排展覽及學校網頁分享(前沿生物科技儀器、細胞培養方法)	4/2019	中學生	20	➢ 資源開放予參與本計劃的八間中學、兩間小學及其他中小學
		2.	參觀及交流 安排展覽及學校網頁分享(中醫藥簡史、中藥資源和種類、香港常見的中草藥)	10/2018		20	
		3. 姊妹學校(　　)	參觀及交流 安排展覽及學校網頁分享(前沿生物科技儀器、細胞培養方法)	6/2019		20	
		4.	參觀及交流 安排展覽及學校網頁分享(中醫療法、中醫診症的特點和方法)	6/2019		20	
	魚樂共生	1. 學生管理及維護		3/2019	中五級學生	50	
〔5〕教師持續專業發展	協作與分享	1. 顧中生物科技研習室儀器和設備的運用	設計課程	11/2018	大學科研工作者及校友、中小學生、全校教師及教職員、家長	60	➢ 資源開放予全校教師及教職員 ➢ 資源開放予參與本計劃的八間中學、兩間小學及其他中小學 ➢ 資源開放予家長
			協作及分享工作坊	11/2018			
		2. 嘉年華會	安排活動	8-10/2019		4000	
			邀請中小學生、家長	10/2018			
			嘉年華會	11/2018			
	課程及興趣班	1. 編寫「遺傳特徵」流動學習應用程式工作坊(共 2 次)	安排課程	11/2018		20	
		2. 齊來認識 DNA	安排工作坊	11/2018		200	
		3. 食療講座	安排講座	11/2018		200	
				總受惠人數		18,174	

(九) 預算

項目	開支詳情	款額 (HK$)	原因
員工開支			
招聘二十三個月合約項目助理 （一個月薪金共$14,000，強積金每月共 $700） （$14,000+$700）x 23 = $338,100		338,100	由於本計劃需建立生物科技研習室、eCourse 生物科技教育平台及 eLife 流動學習應用程式，在當中設計相關實驗及學習資源，懂得相關預備及進行科研實驗的項目助理作技術支援；此員工負責協助推行計劃的行政工作、策劃生物科技的實驗活動及有關 STEM 教育活動
招聘二十三個月兼職合約項目助理 （一個月薪金共$7,000，強積金每月共 $350） （$7,000+$350）x 23 = $169,050		169,050	
招聘十二個月合約文憑教師 （一個月以起薪 14 點計算，每月共$26,700，強積金每月共 $1,335） （$26,700+$1,335）x 12 = $336,420		336,420	由於初中生命科學校本課程、中三至中五生物科技教育及實驗學習活動涉及範圍較廣和需時預備，參與教師須要騰出空間以建立及開發相關的學與教資源；此員工負責教材製作及試教，接替參與教師的教擔與職責，安排生物科技的實驗活動及有關 STEM 教育活動
工程			
顧中生物科技研習室工程	加設工作檯、洗滌槽、水龍頭、更換玻璃門	135,000	設計及製造實驗工作檯、洗滌槽及水龍頭；另需添置空調、抽氣扇、抽濕機、雪櫃，提供一個專業的科研環境以進行實驗
	加設抽氣扇、抽濕機、空調、雪櫃	20,000	
	栽種架、檯及凳等等	15,000	
研習室設備 (計劃完結後，學校承擔維修及實驗消耗品費用)			
DNA 凝膠電泳成像儀 1 部		30,000	把 DNA 凝膠圖像攝錄、列印，應用於一般的科研實驗
凝膠電泳套件 20 套 (gel electrophoresis set)		18,000	用作分離 DNA，應用於一般的科研實驗
自動移液管 10 套 (autopipette)		60,000	應用於一般的科研實驗
組織培養廚 1 個 (tissue culture hood)		70,000	用作植物、微生物、秀麗線蟲等培養，應用於育種、發酵、藥物等科研實驗
恆溫箱 1 個 (incubator)		50,000	
平台式搖蕩器 5 部 (platform shaker)		10,000	用作混合少量核酸，應用於一般科研實驗

微離心機 10 部 (mini centrifuge)		8,000	用作分離少量混合物，應用於一般科研實驗
離心機 1 部 (centrifuge)		3,500	用作分離混合物中各成份，應用於核酸及蛋白質之分離
聚合酶鏈反應器 1 部 (Polymerase Chain Reaction (PCR) machine)		5,000	用於擴增特定 DNA 片段，應用於基因複製等科研實驗
高壓滅菌器 1 部 (autoclave)		12,000	可靠有效滅菌方法，適用於一般科研實驗的細菌培養基等物品消毒
光學顯微鏡 20 部 (light microscope)		50,000	用作中藥顯微鑒定，適用於一般科研實驗
立體顯微鏡 10 部 (stereomicroscope)		55,000	用作分辨秀麗線蟲的基本遺傳，應用於遺傳學等科研實驗
組織培養及聚合酶鏈反應試劑 (tissue culture reagent and PCR reagent kit)		100,000	用作植物、微生物、秀麗線蟲等培養，及擴增特定 DNA 片段，應用於育種、發酵、藥物等科研實驗
eCourse 及 eLife 製作設備	手提電腦 2 部(計劃完結後，留於生物科技研習室繼續使用)	10,000	用於製作 eCourse 生物科技教育平台及 eLife 流動學習應用程式（作業系統須配合學校現有的平板電腦）
	數碼攝錄機 2 部 (同上)	4,000	用於製作生物科技影片
服務			
eCourse 導師服務	每輯 $330 x 20	6,600	聘請大專學生作為 eCourse 生物科技教育平台導師、實驗示範等，共同錄製生物科技影片
eLife 導師服務	每輯 $330 x 20	6,600	聘請校友作為 eLife 流動學習應用程式導師
教師培訓	講座(一次)、工作坊(兩次)	15,000	聘請大學講師或教授，作為講座、工作坊導師
一般開支			
嘉年華	展板製作	1,000	透過嘉年華活動的分享，將生物科技教育的學與教模式及 STEM 教育的經驗、顧中生物科技研習室推廣與社區，普及生物科技教育及有關「健康老齡化」等科研探究
	攤位遊戲製作	1,000	
	實驗活動 / 工作坊 (一次)	3,000	
文件夾、文具、USB、光碟		5,059	推展計劃所需的行政用品
DNA 立體模型材料		2,000	用作製作高小及初中 DNA 立體模型
椰菜花組織培養套件 10 套		20,000	用作椰菜花組織培養
參觀及交流- 旅遊巴士 (來回深圳 45 座位)		5,000	-
印刷開支		20,000	附有光碟的教材套，將相關的學習套件向全港學校推廣（包括郵費）
審計費用		15,000	-
應急費用		22,671	-
		1,622,000	

(十) 計劃評鑑

範疇	項目	簡介	評鑑方法	成功準則
〔1〕課程（中央和校本）的開發、調適和增潤	初中綜合科學科（生命科學）	1. 製作 DNA 平面模型	統計數量	70%參加者完成工作
		2. 製作 DNA 立體模型		
		3. 運用立體顯微鏡分辨秀麗線蟲的基本遺傳	試卷評核	70%參加者合格
		4. 提取 DNA	統計數量	70%參加者完成工作
	中三生物科（生物科技）	1. 栽種藥園(中藥的產量)	問卷	70%參加者感興趣
		2. 編寫 eLife 流動學習應用程式	統計數量	瀏覽次數
	高中生物科（生物科技）	1. 凝膠電泳的分離技術	試卷評核	70%參加者合格
		2. 製作重組質粒及 DNA 指紋分析檢視		
		3. 進行組織培養	問卷	70%參加者感興趣
		4. 藥物檢測		
〔2〕學與教資源的增潤		1. 科研培育計劃	問卷	70%參加者感興趣
		1. 中醫中藥學習活動	問卷	
		1. 血型猜猜猜	問卷	
		2. 益生菌好滋味		
		3. 動植物蛋白質大比拼		
	eCourse 生物科技教育平台 (共 20 輯教育短片)	1. DNA 結構齊填色	統計數量	70%參加者完成工作
		2. DNA 模型製作		
		3. 提取 DNA		
		4. 凝膠電泳的分離技術	統計數量	瀏覽次數
		5. 製作重組質粒及 DNA 指紋分析檢視		
		6. 組織培養		
	eLife 流動學習應用程式	1. 齊來認識 DNA	統計數量	下載次數
		2. 「遺傳特徵」對對碰		
		3. 編寫「遺傳特徵」應用程式工作坊 (共 6 次)	問卷	70%參加者感興趣
	校本評核課業	1. 檢測基因改造食物	得分統計	70%參加者取得良好成績
		2. 探究秀麗線蟲突變遺傳		
〔3〕社區夥伴協作計劃		1. 中藥顯微鑒定(中藥的質量)	問卷	70%參加者感興趣
		2. 提取中藥 DNA		
		3. 中藥認證和成份分析(中藥的質量)		
		1.中藥食療講座	統計數量	出席人數
		1. 建立及維護藥園(中藥的產量)	問卷	70%參加者感興趣
		2. 「認識中藥」流動學習應用程式	統計數量	瀏覽次數
〔4〕學習活動的增潤	參觀活動	1.	統計數量	統計參加者人數
		2.		
		3. 姊妹學校 ( )		
		4.		
	魚藥共生	1. 學生管理及維護	問卷	70%參加者感興趣
〔5〕教師持續專業發展	協作與分享	1. 顧中生物科技研習室儀器運用	統計數量	出席人數
	課程及興趣班	1. 編寫「遺傳特徵」應用程式工作坊 (共 2 次)	問卷	70%參加者感興趣
		2. 齊來認識 DNA	觀察	70%參加者感興趣
		3. 中藥食療講座	統計數量	出席人數

(十一) 計劃的預期成果

1. 中一及中二級綜合科學科生命科學的教材
2. 中三至中五級生物科生物科技及有關生物工程實驗活動的教材
3. 校本生物科技教育的策略、設計和實驗套件
4. 電子學習平台 eCourse 內附有的不同程度的教材和相關資料（照顧學習差異）
5. 學生編寫流動學習應用程式 eLife 的能力
6. 學生學習生物科技的氣氛及學習生物科的興趣
7. 教師及實驗室技術員進行科研實驗及有關 STEM 教育活動的能力
8. 教師熟習並能運用自如的自主學習模式
9. 學生栽種中藥及進行鑒定、認證和成份分析的能力
10. 學生在顧中生物科技研習室進行實驗及對有關的實驗過程及結果進行評鑑的能力及解難能力
11. 有關整個生物科技教育計劃的量化和質化評估
12. 本校所發展的生物科技學與教教材，由本校教師編寫及製作，不受版權限制
13. 本校所發展的生物科技學與教教材版權及各項存放於顧中生物科技研習室儀器擁有權均屬優質教育基金擁有

(十二) 計劃的延續

1. 透過生命科學及生物科技有關實驗活動課程設計，本計劃為學校、學生、教師、家長提供親身接觸生物科技的機會，有利學校日後朝著 STEM 教育方向發展，對所有參與者有著整體增值的莫大裨益
2.

3. 學生熟習並運用電子學習平台 eCourse 及流動學習應用程式 eLife，進行自主學習
4. 透過舉辦校內及校外的分享活動(例如 講座或工作坊)，將生物科技教育的學與教模式及 STEM 教育的經驗(電子學習平台 eCourse、流動學習應用程式 eLife、顧中生物科技研習室的使用)，推廣至其他學校的生物科及理科教師

(十三) 推廣 / 宣傳計劃成效

1. 將教材上載九龍樂善堂教育聯網的學與教資源平台
2. 透過九龍樂善堂轄屬中學聯校品質圈計劃，分享本計劃及相關的教學經驗
3. 透過上載教材至教育城，將相關的學習套件與全港學校分享
4. 透過學校網頁、刊物等形式向家長及全港中小學介紹有關計劃及其成效
5. 邀請中小學生到本校顧中生物科技研習室參觀，了解生物科技教育，並進行交流切磋

(十四) 遞交報告時間表 (本校承諾準時按以下日期遞交合規格的報告)

計劃管理		財政管理	
報告類別及涵蓋時間	報告到期日	報告類別及涵蓋時間	報告到期日
計劃進度報告 01/04/2018 - 30/09/2018	31/10/2018	中期財政報告 01/04/2018 - 30/09/2018	31/10/2018
計劃進度報告 01/10/2018 - 31/03/2019	30/04/2019	中期財政報告 01/10/2018 - 31/03/2019	30/04/2019
計劃進度報告 01/04/2019 - 30/09/2019	31/10/2019	中期財政報告 01/04/2019 - 30/09/2019	31/10/2019
計劃總結報告 01/04/2018 - 29/02/2020	31/05/2020	財政總結報告 01/10/2019 - 29/02/2020	31/05/2020

(十五) 本校在進行科學實驗時，將遵從《科學實驗室安全手冊(2013)》內所列安全措施，以提高學校的安全水平。

(十六) 本校會確保更改房間用途的工程是遵照有關法例進行。

(十七) 整個計劃的工程部分不涉及結構性改動，同時已取得相關政府部門的批文

(十八) 資產運用計劃

類別	項目／說明	數量	總值	建議的調配計劃(註)
視聽器材	手提電腦	2 部	HK$10,000.00	
	數碼攝錄機	2 部	HK$4,000.00	
設備	DNA 凝膠電泳成像儀	1 部	HK$30,000.00	計劃完結後，所有 視聽器材及設備 繼續於研習室使用
	凝膠電泳套件	20 套	HK$18,000.00	
	自動移液管	10 套	HK$60,000.00	
	組織培養廚	1 個	HK$70,000.00	
	恆溫箱	1 個	HK$50,000.00	
	平台式搖蕩器	5 部	HK$10,000.00	
	微離心機	10 部	HK$8,000.00	
	離心機	1 部	HK$3,500.00	
	聚合酶鏈反應器	1 部	HK$5,000.00	
	高壓滅菌器	1 部	HK$12,000.00	
	光學顯微鏡	20 部	HK$50,000.00	
	立體顯微鏡	10 部	HK$55,000.00	

參考資料 / 書目

1 自主學習：
http://sdls.cite.hku.hk/hk/what-is-self-directed-learning/
差異化教學 / 區分性教學：
http://www.edutopia.org/blog/differentiated-instruction-ways-to-plan-john-mccarthy
http://www.readingrockets.org/article/what-differentiated-instruction

2 「發現學習」布魯納 (J.S.Bruner) 的學習心理學：
http://chiuphysics.cgu.edu.tw/yun-ju/CGUWeb/SciLearn/theory/Bruner00.htm

3 課程發展議會 2015《推動 STEM 教育發揮創意潛能》概覽

Part B Project Summary

Project Title: *(Please fill in the blank)* Laboratory in your pocket - Real-time hand-on experiments on Microcontroller-Smartphone Platform	**Project Number 2016/1098 (Revised)**

Name of Organization: Department of Applied Physics, The Hong Kong Polytechnic University

(1) Goals: Enhance the L&T experience through flipped classroom learning mode in DSE physics by providing access to well-designed Microcontroller –Smartphone based experiment.
Objectives:
(i) To implement a platform that utilizes the microcontroller-smartphone system for extracting data collected by various physical sensors
(ii) To devise assignments with guidelines on report writing for DSE physics experiments, utilizing the developed microcontroller-based smartphone as the measurement tool
(iii) To assess the impact of introducing project-based learning on students' motivation in physics studies and their understanding in specific physics topics

(2) Targets: Secondary School, Physics teachers and DSE physics students
Expected number of beneficiaries: Teachers: 40; Students: 450

(3) Implementation Plan:

(i) Duration: Mar 2018 – Feb 2020
(ii) Process / Schedule: Phase 1 Establishment and Pilot Run of Prototype Experiment (Mar 2018 - May 2019); Phase 2 Implementation of Two new Experiments and Promotion of the Fully-Developed Platform (Jun 2019 - Feb 2020)
(iii) Collaboration with other parties / partners: 5 target partner schools

(4) Products:

(i) Deliverables/outcomes:
A central platform for performing microcontroller-smartphone based experiments, with a collection (40 sets) of equipment and the corresponding sensors.
(ii) Dissemination of deliverables / outcomes: Short Video
(iii) Commercialization potential of deliverables / outcomes:

(5) Budget:

(a) staff cost: $149,100; (b) equipment: $401,980; (c) services: $51,280; (d) works; (e) general expenses: $30,042; and (f) contingency: 14,498.

(6) Evaluation:

(i) Performance indicators:

User-feedback questionnaires; User Registration and Visit Logs to the Platform: Frequency of Visits ; Utilization feedbacks for various experiments; Interviews

(ii) Outcome measurements:

User-feedback questionnaires; User Registration and Visit Logs to the Platform: Frequency of Visits ; Utilization feedbacks for various experiments; Interviews

Project Details
Laboratory in your pocket - Real-time hand-on experiments on Microcontroller-Smartphone Platform

Needs and Applicant's Capability

a) Needs Assessment: An evaluation of the current situation and the needs for the present project

STEM Education Reforms in Hong Kong

In the Policy Address of 2017, Chief Executive stressed the importance of reforming the Education System in Hong Kong. EDB will strive to promote Science, Technology, Engineering and Mathematics (STEM) education. Of course, students must be the focal point of the STEM Education Reform [1]. Among the various priorities in the STEM education reform, fundamental science training is no doubt being the key issue in the reform. Students with high-level science capability, if properly nurtured, will become crucial contributors to the more advanced, knowledge-based and technological society. On this premise, good science education helps achieve betterment of Hong Kong Society.

Without doubt, laboratory teaching is an indispensable part of science education [2]. The processes of making observations, performing systematic and quantitative investigations with meticulous control of the experimental parameters, data collection and analysis, subsequent logical interpretation of results and drawing relevant conclusions, are the skills fundamental to the training of *all* science as well as technology and engineering subjects. Performing experiment also serves to reinforce students' classroom learning experiences. Well-controlled laboratory settings provide students with first-hand experiences to the relevant scientific phenomena and verify their knowledge acquired from textbooks.

Ironically, many of the scientific ideas covered at secondary school levels are taught with only very limited support of the corresponding experiments, for a number of reasons: 1) experiments require many sets of equipment in order for the students to perform the experiments by themselves during the class period, high schools require lots of budget as well as space to maintain the large number of experimental set up; 2) some experiments may pose risks associated with the handling of the apparatus and materials to untrained personnel (students in particular); 3) some involves experimental setups that are highly specialized. Teachers may also lack knowledge and experiences in handling and maintaining such equipment, and they may not even have used such facilities during their undergraduate studies; 4) time is another important issue that obstructs the teachers to arrange enough experiments in their teaching schedule. General speaking, the syllabus of science subjects in high schools is very tight and packed, thus it is very difficult for high school teachers to arrange enough laboratory time for the students to perform experiments during class time.

Faced with these limitations, typical solutions, either to perform slide/video shows of the related experiments or to run computer simulations based on textbook equations and models, are suggested. While such alternative learning and teaching (L&T) approaches provide supplementary information to students about the scientific principles involved, there are pitfalls associated with these techniques: 1) Video/slide demonstration as a learning mean is highly passive in nature. Students are forced to receive information from the videos/slides as they are, without the opportunity to verify and challenge the concepts by performing the laboratory work themselves; 2) For computer simulations, in many cases subtle details are neglected simply because of their irrelevance to the main scientific phenomena under consideration. For example, increasing the separation between the sound source and the receiver naturally leads to a reduction in the detected sound intensity (inverse-square law), irrespective to the presence of interference or diffraction effects. The absence of such features convey a naive message that real-life experiments have simple correspondences between the experimental parameters and the observables discussed, and are free from other potential influences. Including such complexities in simulation, while possible, is cumbersome and it involves a tricky balance between highlighting the specific phenomena and the complexity of the real-world situations. Additionally, as simulations always yield 'perfect results', students are deprived of the opportunities to understand how randomness, imperfections and errors can arise in real experiments. For example, randomness in radioactive decay processes is inevitable and can be systematically analyzed, while systematic errors or instrument noises can be suppressed with proper experimental techniques. The discussion of such 'imperfections' are also of significance for scientific studies. Therefore, **real-time hand-on experiments** are indispensable part of STEM education.

In order to tackle the problem of limited real-time hand-on experiments in high schools, we propose to adopt a centralized depository of selected experiments based on **Microcontroller-smartphone Platform** for improving the physics learning experience of senior secondary students (Microcontroller such as). This platform will use the students' smartphones connected onto an system as the measuring tool. Smartphones are different from computers or

notebooks in computer lab because the smartphone is personal technology. Most students have invested a great deal of time learning about the features as well as the limitations of the smartphones. They know how to navigate smartphones well. The other reason to really rethink the smartphone debate is because learning on the smartphone can extend beyond the walls of the school or the confines of a class period. Some people may want to ban smartphones from classrooms, however, we didn't ban pens in our schools because students can pass notes during class. The pencils have also survived even though you could poke someone in the eye. This is a new time in education and with dwindling budgets, so we need to rethink possibilities, stretching every dollar. These mini computers are walking through the school doors each day, let's put them to work.

Most of smartphones embedded several sensors such as light sensor, proximity sensor, magnetometer and accelerometer. These sensors can be used to perform simple physics experiments in education purpose. There are several advantages of using sensors in smartphone comparing to those experiment kits used in school. For example, all those sensors can be controlled by the phone and record data simultaneously. It greatly reduces the complicated connection. It is portable which can perform the experiments without location restriction. Although these experiments based on the built-in sensors have several advantages; however, number and type of sensors in smartphone are limited. Thus, it limits the kinds of experiments that can be performed. For some specific or complicated experiments such as voltage and current sensor in physics experiments, gas sensor and pH meter in biology or chemistry experiments are not presented in most of the smartphones. Fortunately, these specific sensor modules are mostly available in market. Figure 1 shows several common-used sensor modules such as force sensor, motion sensor and humidity sensor. These sensor modules are cheap and easily obtained from market but they are not compactable with most of the smartphones and need an interface in order to be used with the smartphones. Even with those sensors that are compactable with the smartphone, the number of sensors that can simultaneously connect to the smartphone is limited i.e. smartphones usually can connect with one to two external sensors. Thus, in order to perform experiments using more than two sensors, an additional interface system will be required between the smartphones and sensors. Another reason for not connecting the sensors directly to the smartphones is that when the sensors are connected to the smartphone during experiments, the smartphone will be at risk as the signal from the sensors is directly connected to the smartphone without protection. Therefore, it will be better if we can have a interface/data-logger that communicate between the smartphones and sensors, and at the same time allows many sensors to be connected.

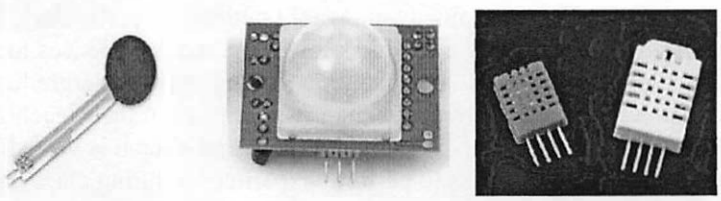


Figure 1) Force sensor, motion sensor and humidity sensor

Among various types of connectors used to communicate between smartphone and sensors, is preferred because of its low cost and small size. In our proposal, will be used as a universal interface as well as data-logger between sensors and smartphones. Figure 2 shows an (without and with Bluetooth embedded) which can be used to configure the sensors and received the digital or analog signal from the sensors. General speaking, the sensors will be connected to the board through USB connectors. Figure 3 shows an alcohol sensor and temperature sensor which have been connected to a USB connector and can be coupled onto an board easily. With the help of a 3D printer, our team has developed a hosting case which is used as a data logger as well as interface box to collect data from sensors and successfully transmitted the data to smartphone through Bluetooth or Wifi.

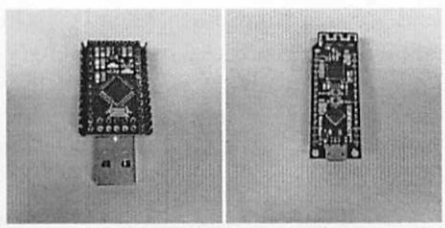


Figure 2) board without (left) and with (right) Bluetooth embedded

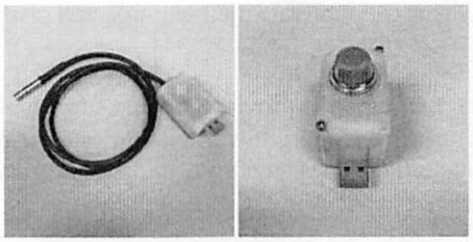


Figure 3) Alcohol sensor and temperature sensor

Figure 4 shows the data logger with six sensor ports. Different sensors can be connected to the hosting case system through USB plug. The system will be powered by portable battery pack. Figure 5 shows the whole setup including the smartphone, a temperature sensor, data logger case and a portable battery pack. The screen on the smartphone shows that signal is collected via the data logger using the Bluetooth technique.

Figure 4) Data logger with six sensor ports

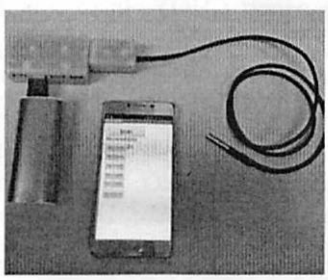


Figure 5) Whole setup include smartphone, temperature sensor, data logger case and portable battery pack

These sensors provide an interesting possibility of performing experiments inside/outside school laboratories, dramatically increasing the potential experiments and even permit project-type experiments in many science subjects, in particular, Physics and Chemistry. By using this **flipped classroom learning** mode based on our proposed platform, we intentionally shift teaching and learning to a learner-centered model in which class time is dedicated to exploring topics in greater depth and creating meaningful learning opportunities for students.

In this proposal, the proposed Eight experiments are either not normally installed in secondary schools or those experiments which are strongly correlated to daily life. The smartphone platform allows students to perform the experiments during lunch time or after school. Indeed, the flexibility of this platform can provide various L&T modes to be adopted as deemed suitable by teachers. For example, teachers can use a particular setup for in-class demonstrations i.e. the teachers select suggested experiments within the curriculum. The platform also provides a channel for conducting group-based investigative studies as well as science projects. We should stress that the latter type of investigations is particularly suited for the Investigative Studies as proposed in the DSE Physics curriculum. Furthermore, this platform allows students to perform experiments and submit their own experimental reports to their teachers. In this case, teachers can use this platform as one of the school-based assignment (SBA) tasks. Currently schools are faced with difficulties in providing sufficient equipment and projects to encourage students to take part in investigative study, and many of them opt for long laboratory reports as an alternative. Furthermore, this platform also encourages inquiry based learning (IBL) among secondary school students. The present platform thus offers a possible solution for schools to handle such a task and to provide students with an exciting learning opportunity. Accompanying the platform are supporting materials that can be used to facilitate various L&T as well as IBL approaches. This platform also provides a scaffold for students to take and analyze a large number of good quality data. In traditional experiment lessons, students can only take a very limited number of data during class experiments (due to limited time and/or limited set of equipment) and try to get the results by analyzing only a few data points. This platform gives students a chance to learn how to analyze many data points and draw a reasonable conclusion based on such analysis. Besides, this platform allows students to repeat the

experiments based on their own requests. This can motivate their learning and give them chance to perform an experiment that up to their own standard.

On the basis of these proposed tasks, this platform will provide an ideal flipped classroom learning experience to senior secondary school students. The well-designed interface with various sensors, assignments, laboratory manuals as well as learning materials will be developed which will be allocated to secondary students. The capability of such learning tools in enhancing the students' learning experience will be investigated.

In summary, the objectives of the current project are:

1. To implement a platform that utilizes the microcontroller-smartphone system for extracting data collected by various physical sensors
2. To devise assignments with guidelines on report writing for DSE physics experiments, utilizing the developed microcontroller-based smartphone as the measurement tool
3. To assess the impact of introducing project-based learning on students' motivation in physics studies and their understanding in specific physics topics

As the ultimate users are DSE students and their science teachers, secondary schools play a crucial role in the sustainable development of the platform. Secondary school partners will be involved in the design and implementation of experiment setups as well as associated teaching materials. They also help us to incorporate such setups in the teaching of related topics.

b) Readiness of the applicant organization for undertaking the project

Goals and Objectives

The main purpose of this project is to enhance the L&T experience through flipped classroom learning mode in DSE physics by providing access to well-designed -smartphone based experiments. It should be stressed that authentic, hands-on laboratory experience cannot, and should not, be replaced by virtual experiments and/or demonstrations; the positive intellectual impact of hands-on experiments, as successfully performed by students, is undeniable. In reality, as mentioned in the first section, many constraints prohibit students from getting access to such hands-on experiments. The -smartphone based experiment platform, we believe, is a good solution to the situation. The capability of such learning tool in enhancing the students' learning via this proposed -based laboratory platform will be investigated.

Short Term Goals

The immediate goal of the project is to provide selected physics experiments on topics at senior secondary levels through the smartphone based experiments which are intellectually stimulating but generally easily to be performed in daily life environment. Four based experiments are planned in Phase I of the project, covering mechanics in the core DSE curriculum as well as environment and energy in the elective part. Supplementary materials will be prepared to facilitate classroom teaching by teachers and guided experiment sessions performed individually by students. Through the use of such platform, students are expected to grasp a more thorough understanding of the corresponding topics in physics. The degree of how such goals are achieved will be assessed during the project duration. Furthermore, four more smartphone based experiments will be designed and implemented in Phase II of the project. A unique platform for students/teachers to download the experiments or upload the students' reports as well as their own designed -smartphone based experiments will be established. The performance of this platform will be tested during the project period. The project effectiveness will be evaluated by the end of the project.

Long Term Goals

The project could evolve into a self-sustained mode and as an exemplary model of efficient utilization of education resources among secondary schools. Based on experience gained in this project, it is expected that -smartphone based experiments at various levels could be designed for students in different stages of education, and thus maximizing the functionalities of the platform. Know-hows of developing these -smartphone based experiments and attaching them to the platform will be passed on to teachers of participating secondary schools. The platform allows the teachers/students to develop their **own** interesting -smartphone based experiments and upload into our platform to share their whole experiences. The workshops in this project also served to disseminate these skills and ideas to more secondary school teachers. At this stage, AP at PolyU will be playing a supporting role, providing technical consultancy to school teachers when the need arises. With the platform established, individual schools can therefore implement experiments and activities that are deemed suitable for their students, and share their experiences/outputs through the platform. Besides, students' active participation in the construction of the experiment would boost their interests in high-level science learning and engineering design practices.

In summary, the objectives of the current project are:

1. To develop a mircocontroller-smartphone based platform with eight experiments covering various topics in DSE Physics that allows extracting the data collected by physical sensors within the smart phones. This platform should include:
   a. A web-based remote-login system that allows the users to log-in the system and download the information of the microcontroller-smartphone based experiments or uploads their own developed experiments.
   b. Auxiliary materials or assignments with guidelines accompanying specific experiments, for the perusal of school teachers to use the platform for various teaching activities. These include demonstration videos showing the procedures of the microcontroller-smartphone based experiments, self-contained laboratory manuals for performing experiments at various levels (individual work, group-based learning assignments, investigative-studies type projects or inquiry based learning), teaching notes/instructions concerning the specific microcontroller-smartphone based experiments and potential investigative project suggestions based on the capabilities of the setups.
2. To devise assignments with guidelines on report writing for DSE physics courses, utilizing the developed microcontroller-smartphone based setup as the measurement tool.
3. To assess the impact of introducing project-based learning on students' motivation in physics studies and their understanding in specific physics topics. To evaluate the effectiveness of the platform, as in contrast with other teaching means (virtual reality simulations, displaying of video shows, etc.) generally used for teaching scientific concepts when the access to authentic laboratory setups are hindered.
4. To create engaging and effective inquiry based learning activities in secondary schools based on the uniqueness of this platform. A series of activities will be developed in order to guide students through the platform to scaffold their investigations. Through this platform, students can create their own personally relevant questions and try to answer them.

Targets and expected number of beneficiaries

- Students enrolled in the DSE physics curriculum in participating schools will be the primary group benefited from the project. The total number of students involved is estimated to be **450**, based on the number of participating students (around 45 for each school) in each participating schools (10 schools in total).
- Physics teachers in the participating schools (~20 teachers with 2 teachers per participating school) will be benefited from the provision of teaching materials and the experiment setups for conducting their teaching. They will also acquire the knowledge on the design principles and techniques of building new setups in the platform. Among these 20 teachers, half of them are project team members who will also involve in the design of teaching materials as well as supporting materials. A series of teacher development workshops will be organized subsequent to the completion of the learning activities of each of the two phases. It is expected that a total of two workshops will benefit around 200 school teachers. Therefore, we estimate about 220 teachers will be benefited.
- At the final stage of the project, a booklet and a website will be produced to compile the results of the project. Based on the study of the effectiveness of this platform on the L&T of the DSE students, educational papers will be published in international journals. These tangible deliverables are of benefit to a large number of stakeholders in both the local and oversea education community.

Implementation Plan and Timeline

-smartphone based experiments Platform

In this platform, registered users (students/teachers from the participating schools) can securely login to a server hosted in PolyU, which grants access to the proposed platform which is responsible for the users to download the information of the experiments, teaching materials including the laboratory sheets, background reading as well as supporting materials etc. Demo video is also available for the users to visualize the experiment 'in action'. Through the booking system available in the platform, school teachers can borrow the hardware of the experiments, such as the system and corresponding sensors. In this proposal, we suggest to develop 40 sets of hardware (including the and different types of sensors). In additional, the design as well as the fabrication information can be obtained in the platform for those teachers will want to build their own system in their high schools.

The platform will not be just designed as one-way platform, but also acts as an interactive platform among the users. A forum will be available for the users to share their comments/feedbacks among themselves. In the forum, users can upload any suggested -smartphone based experiments for further development/discussion or even their own developed -smartphone based experiments into the platform.

Based on the above mentioned concept, the platform should contain the following components:

1. A log-in system which allows registered users to gain access from smart phones and/or computers to the platform hosted at PolyU. The log-in system should possess the following functions:
   - providing necessary security features to ensure access to the system only by registered members;
   - permitting users to download the teaching materials of the experiments for conducting specific experiments;
   - allowing the users to upload their experimental reports to the platform so that their corresponding school teachers can access their reports.
   - providing a booking system for teachers to borrow the developed hardware (and sensors) from the platform.

   After logging into the system, background materials as well as a demo video will be provided to make sure that the users/students have enough information on carrying out the experiments. In this system, the users can share their opinions among other users, and this definitely facilitates self-learning among secondary students.

2. 40 sets of experimental setup including the -based data logger boxes and various types of sensors are necessary for performing the experiments. For example, one of the main components for mechanics experiment is the accelerometer which is almost a standard component in the smart phone. In this project, we propose to build 40 sets of -based data logger boxes which allow school teachers to borrow. In additional, apart from the data logger boxes, 40 set of various sensors including those sensors not commonly available such as PM2.5, UV and pH sensors, will be also available for the high school teachers to borrow for performing experiments.

3. A webpage based platform interfacing the users will be established. To facilitate peer learning among students, a forum will be setup in the platform so that the feedbacks/comments from the users will be shared among themselves.

4. Supplementary L&T materials related to the experiments will be developed. We will design our supporting materials (in English as well as Chinese) based on three approaches that we expect students/teachers would utilize the setups:

- as a class demonstration of relevant phenomena in DSE curriculum;
- as a take-home individual or group assignment; and
- as a setup for conducting Investigative Studies to enhance inquiry based learning (IBL).

5. The following materials will be prepared accordingly to facilitate the teachers when performing the above mentioned tasks:
   - Short videos on the procedures of logging into the system and operating the setups. Sample videos showing the user how to perform the experiments will also be prepared, illustrating the physical phenomena expected to be observed from the experiments.
   - Background information on the physical phenomena will be provided in dedicated webpage, accessible directly from the experiment site.
   - Laboratory worksheets to guide the students through the experiments. Structured questions will be prepared, through which students will practice their skills in making observations, doing analysis and drawing conclusion by performing the tasks sequentially. Separated worksheets will be prepared to cater for group-based experiments, in which students will solve problems of greater complexity through discussions. Instruction sheets for proposed Investigative Studies projects based on the -smartphone based setups. Currently, students use long experimental report to fulfill the requirement of the SBA requirement of the DSE Physics curriculum; with the platform, students can design their own investigations or make refinement based on our designed experiments so that teachers can use these investigation studies as their SBA assignments. Brief guidelines and experimental techniques will be provided, as the purpose of providing such instruction sheets is to kick-start the brainstorming process among students in deciding their project objectives and experimental methods.

Choice of Experiments

Experiment 1: Monitoring the Environmental

Environmental issue has been an interesting topic for the new STEM education. Selection of this experiment into the platform will provide students with their own hands-on experience to measure several important parameters in learning environmental protection. Using PM2.5 sensor, UV sensor and pH sensor, students can grasp a general idea of how to measure air quality, UV radiation and rain acidity at location near their school. By integrating a card into the system, students can use the whole setup to monitoring the pollution factor for a long period. This remote-access arduino-smartphone based setup eliminates the potential hazards (such as long exposure time under the sun) to students, and yet allows them to acquire the related experimental techniques and concepts. Furthermore, in this study, more than hundred data points will be collected. This gives students a chance to learn how to analyze a large number of data points and draw a reasonable conclusion based on such analysis.

Experiment 2: Monitoring the growth of a plant.

During the growth of a plant, a lot of factors will affect the growth of the plant. This experiment allows the students understand the effects of various parameters, such as temperature, humidity, amount of O_2 and CO_2 on the growing process of a plant. The remote-access arduino-smartphone based setup eliminates the potential hazards to students as well as long experimental time, and yet allows them to acquire the related experimental techniques and concepts. By integrating a card into the arduino system, we can allow the students to monitoring all the growth parameters of the plants in a long period of time and yet can eliminate the time consuming procedure.[7]

Experiment 3: Magnetism

Magnetism is one of the important topics in HKDSE Physics curriculum. A current carrying wire generates magnetic field which is the basic working principle for electromagnet. The magnetic field strength depends on the various factors, including applied current, structure of the wire-formed (circular loops or solenoid, Number of turns of the coils) and permeability of the medium. The -smartphone based experiments platform which integrated both the current source and magnetometer. Students can control the applied current through the platform and investigate the relationship of magnetic field strength of circular coils / solenoid and record the data simultaneously. Different structure of coils / solenoids will be provided and allow students to investigate the magnetic field strength.

Experiment 4: Gas Law

The Gas Law describes the relationship between pressure, volume, the number of atoms or molecules in a gas, and the temperature of a gas. Student can investigate the relationship between pressure, temperature, volume, and the amount of gas occupying an enclosed chamber by the -smartphone based experiments platform. Mostly, the measurement required an equilibrium/ steady-state in temperature which is a time consuming procedure. This is a challenging task for teachers/students to finish the experiment in the class with limited time. By integrating a card into the Arduino system,

teachers/students can use the whole setup to monitoring the process of the experiment and have a hundred of data in pressure and temperature.

Schedule of Project

Phase 1: Establishment and Pilot Run of Prototype Experiment

Phase 1a: Adoption of the hardware for prototype experiment

At the start of the project, the server system of the existing PolyU-based experiment platform (developed in the QEF project (2013/0127)) will be adopted and strengthened. Our preliminary version of the ·smartphone setup will be modified to perform the proposed experiments. Meanwhile, four smartphone based experiments including the hardware and the teaching materials will be developed. The setups are chosen due to their board impact and the lack of such experiments being conducted in secondary schools. At the same time, corresponding L&T materials will be drafted for students' laboratory work and teachers' classroom teaching purposes. As there are two types of school in Hong Kong, namely, Chinese as Medium of Instruction (CMI) and English as Medium of Instruction (EMI), we propose to develop the experiments in bilingual mode, so that both CMI and EMI schools will be facilitated. In addition, help desk service and "Frequent Q&A" section will be provided.

Phase 1b: Pilot-run and assessment of prototype setup in partner secondary schools

Once the experiment setup is established and is supplemented with the corresponding L&T aids, the -smartphone based experiment platform will be pilot-run in the five partner secondary schools for evaluation. During the test period, the functionalities of the hardware as well as the teaching materials will be thoroughly tested by students and teachers of the participating schools. At the end of the test period, students and teachers of the five partner schools will be invited to take part in a survey on their opinions about the experiments. Comments concerning (but not limited to) the following technical aspects of the platform will be collected:

- Reservation and login system: Ease of access to the system, stability of system, functionality of multiple user-login features, User-friendliness of interface, etc.
- Hardware: User-friendliness of the systems; Functioning of various components (stability of systems, sensor performances, quality of experimental data, Bluetooth communication); ease of control.
- Supplementary L&T materials: Accuracy, clarity and attractiveness of background information and laboratory manual; effectiveness of L&T aids in stimulating self-motivated learning among students; clarity of video of experimental setup.

Phase 1c: Promotion of microcontroller-smartphone based experiments at various occasions and Organizing the 1st Workshop: Knowledge transfer to school principals/teachers

Promotion of the -based experiments will be conducted via various channels, with the target audiences being secondary school teachers and students:

- Demonstration sessions will be conducted during the annual Information Days of PolyU in summer, during which the actual setups will be displayed to the visitors.
- Participating secondary schools will provide demonstration sessions of the platform during their school Open Days, with posters featuring the functionalities of the system displayed to enhance the publicity effect.
- Publicity will also be made via the publicity channels of PolyU, Video footages showing the operation of the experiments will be displayed on the department website, as well as the : channel of PolyU [3].

A teacher development workshop will be organized to introduce our new developed -smartphone based experiments to secondary schools in Hong Kong. This workshop also provides a forum for secondary school teachers, principals and educators to interact and share their experience in laboratory teaching. To enhance the long-term sustainability of the project, school principals and teachers will be invited to take part in the design and construction of four new sets of -smartphone based experiment not specified in this proposal. Workshop will be organized for teachers and students during summer holidays, detailing the concepts and technical issues in building setups that are compatible with the platform. Interflow sessions will also be held, providing an arena for the schools to share their ideas and challenges faced.

Phase 1d: Launching of Modified Platform (with four experiments) to more secondary schools

After collecting information and feedback from the partner secondary schools for the pilot-run, modifications will be made to improve the experiments' performances and functionalities. From this point onwards, modified setups will be launched sequentially to more secondary schools (with a target of not less than 5 more secondary schools other than the five partner schools).

Although the teaching schedules among schools may vary in details, it is anticipated that there are some similarities in the sequence of coverage in the topics among different schools. The demand for a particular setup may, therefore, be peaked within a short period of a few months but is otherwise seldom used for the rest of the year. To make the best use

of the setups throughout the year, participating schools will be encouraged to design investigative projects based on the experimental setups. Students will be given access to a particular setup and allowed to make simple adaptations to fulfill the needs of their investigations if necessary. This is not expected to be a major problem for other teachers and students, who use the platform mainly for L&T purposes: the investigative studies are generally done once or twice every month for each group. Supporting materials will be provided to schools for brainstorming of project ideas based on the available setups, as discussed previously.

Phase 2: Implementation of Four new Experiments and Promotion of the Fully-Developed Platform

Phase 2a: Implementation of four smartphone experiments with the feedback from secondary schools

It is desirable to have different sets of experiments rolled out one after another. This would allow the accumulation of valuable experiences in constructing and improving the experimental setups. The modular design concept serves to simplify the process of constructing different experiment setups, as they can be built by schools through assembling of various modules with necessary sensors. Complicated electronics for data sensing, encoding and communications are hidden away from the students in black boxes. This would have the effect of encouraging students to take part in the experiment construction process. Afterwards, the newly developed experiments will be launched to all the participating schools for evaluation. Besides school principals and teachers' views in the design and construction of the four new sets of experiment in Phase II, views from Science Education Section of Curriculum Development Institute, EDB will also be sought to meet the curriculum objectives.

Phase 2b: Evaluating the impact of the platform on L&T experience

Focus group of teachers from the participating schools will be formed. Information on how the experiments affect their teaching and how the experiments perform will be collected. Furthermore, another focus group of students from all the participating schools will also be formed. The evaluation will be shifted and concentrated on how the experiments enhance and enrich the students' learning of DSE science related subjects.

The smartphone based experiments are built on the belief that it is a preferred solution when there are difficulties for students to perform experiments in their school laboratories. The main focus of the evaluation is therefore to compare the -smartphone based experiments with other alternative, when the schools are faced with identical constraints. These alternative solutions include the use of multimedia clips featuring specific experiments, as well as computer simulations. Teaching without the use of any additional L&T aids will be considered as control cases.

To assess the effectiveness of the aforementioned L&T methods [4], pretests will be issued to all students to ensure the even distribution of their intellectual capabilities. After the performance of -smartphone based experiments, short quizzes will be conducted on students who have been taught on the same topics with different L&T means, and their performances will be (anonymously) assessed. Interview sessions will also be conducted with teachers and students using different modes of teaching to cover the same topic, evaluating the merits and shortfalls of different types of techniques. Such assessments will be done about three months after the experiment setups are launched. The feedbacks obtained will be used for refinement of the setups and the supporting materials.

At the end of the project duration, a panel of independent experts will be formed for conducting a comprehensive evaluation on all the aspects of the project, performing a SWOT analysis on the prospects of the platform. Further elaborations of these evaluation methods will be discussed in the later parts of this proposal.

Phase 2c: Organizing the 2nd Workshop

In this workshop, we will invite more secondary teachers and introduce the platform as well as the smartphone based experiments. We will also share the experiences as well as the impact of the platform on L&T experience in the participating schools.

Implementation Timeline

	Mar 2018 - May 2018	Jun 2018 - Aug 2018	Sep 2018 - Nov 2018	Dec 2018 - Feb 2019	Mar 2019 - May 2019	Jun 2019 - Aug 2019	Sep 2019 - Nov 2019	Dec 2019 - Feb 2020
Phase 1								
Establishing hardware for the four prototype experiments	■	■						
Pilot-run of prototype setup in the five partner secondary school			■					
Assessment of pilot-run setup			■					

Modification of the four ' -smartphone based experiments								
Promotion of platform at various occasions								
1st Workshop: Training Workshops on Platform								
Launching of modified experiments to other participating secondary schools								
Full Evaluation on the four Experiments								
Phase 2								
Design and Construction of the four more -smartphone based experiments								
Launching of fully-developed Experiments in both partner and participating secondary schools								
Second Full Evaluation on the smartphone based experiments								
2nd Workshop								
Final Evaluation on the Project & Concluding Report								

Table 1 Project timeline

Expected Deliverables and Outcomes

At the end of the project duration, the following deliverables are expected:

1. A central platform for performing microcontroller-smartphone based experiments, with a collection (40 sets) of equipment and the corresponding sensors. Such setups will be made accessible to registered secondary school teachers and students.
2. Supplementary L&T materials for various experiments. These include background and supporting teaching materials, laboratory manuals, and websites with information relevant to particular experiments for both teachers and students.
3. Skills on the know-hows of constructing similar microcontroller-smartphone based experiments and incorporating them into the platform. Skills and experiences will be accumulated and passed onto teachers and students of participating schools.
4. On the basis of the investigation of the effectiveness of this platform on the new DSE Physics teaching, we might publish educational papers in international journals so that both the local and oversea education community will be benefitted.

These deliverables will be aligned with the intended learning outcome of the experiment platform:

1. To enhance the understanding of the scientific phenomena through operations of the microcontroller-based experiments.
2. To understand the functions, strengths and limitations of various instruments and experimental setups based on the microcontroller-smartphone system.
3. To develop an interest in self-motivated and independent physical science learning through online project-based investigations.

Safety Measurement for Secondary School

As some of experiments may be conducted in laboratory in secondary school, laboratory safety measures will be taken and the "Safety in Science Laboratories", Education Bureau, 2013 will be observed.
http://cd1.edb.hkedcity.net/cd/science/laboratory/safety/SafetyHandbook2013_English.pdf

Evaluation Methods, Parameters and Plans

Methods and Parameters

Several approaches will be employed to examine the extent to which the project objectives prescribed in this proposal are achieved, bearing in mind the experiment platform should also attain the intended student learning outcomes.

User-feedback questionnaires

Questionnaires will be issued to teachers and student users. Survey form for students will cover aspects on the general impression of the platform (visual appeal, user friendliness, content of supporting information). More technical questions will be posed to the teachers, focusing on issues such as the design of experiments, accuracy of information, responses of students towards the -smartphone based experiments. Results extracted from these surveys will be analyzed and their implications on the platforms' effectiveness as L&T means will be determined.

User Registration and Visit Logs to the Platform

The impact and effectiveness of the experiment platform will also be inferred by the webpage statistics extracted regularly (for example once a month) from the server, which are indicators of the performance and popularity of the system:

- *Frequency of Visits*: The **hit-count** for the server of the platform is a 'popularity' indicator of the platform amongst students. As the platform also hosts useful L&T materials related to the experiments, it is expected to be a popular means for enhancing students' learning experience.
- *Utilization feedbacks for various experiments:* For example, the **number of registered users** indicates whether students and/or teachers are interested in the idea of -smartphone based experiments. On the other hand, subsequent **login counts** by users after registration can reveal the appeal of the platform to students (assuming the experiment is of appropriate level and does not require multiple accesses by students to finish one single experiment).

Interviews

Interview sessions will also be conducted with teachers and students using different modes of teaching to cover the same topic, evaluating the merits and shortfalls of different types of techniques.

Expert Reviews

The fully-developed platform, experimental setups and supporting materials will be comprehensively reviewed by an independent panel, consisting of colleagues from EMB and physics/engineering/education departments of local tertiary institutions and secondary schools. Aspects such as the design of the experiment, user experience, supporting L&T material qualities will be thoroughly examined. Special emphasis will be made on the effectiveness of the platform in helping students achieve the intended learning outcomes. During the review process, all the data and information obtained by the aforementioned methods will be evaluated by the panel, based on which a holistic picture about the effectiveness of the platform can be drawn.

Evaluation Plan

Pilot Run Stage	
- Aim of Evaluation	To assess the functioning of the platform and gather user feedback for potential improvement
- Methodologies	- Meetings with users (teachers and students) to gather opinions on the qualities of deliverables. - Survey forms to students and teachers for feedbacks on the usability and potential implications on intended learning outcomes - Gather information on usage patterns based on site visit and user registration/login records.
Full Development Stage	
- Aim of Evaluation	To fully assess the suitability of the . -smartphone based experiments platform in achieving the intended learning outcomes and its impact on students' science learning.

- Methodology	- Comprehensive user (teacher/student) survey on the effectiveness of the platform for science teaching/learning, and the extent in which the intended learning outcomes are achieved. - Pre-tests and post-quizzes for students to assess their understanding of the related topics. Pre-tests are necessary to benchmark their abilities before the start of the L&T activities.[4] - Gather information on usage patterns based on site visit and user registration/login records. - Expert review panel to adjudicate the performance of the platform.

Sustainability of the outcomes of the project

The sustainability of the outcomes in this project relies on the continual functioning of the platform as alternative L&T means. Part of the project plan is to disseminate the responsibilities of constructing and hosting new setups to the participating schools. As mentioned previously, the platform allows the establishment of . -based experiments for different topics using the . system and various sensors. Knowledge transfer through workshops within the project duration allows the know-how of constructing the experiments to be spread among secondary school teachers, who can develop other setups and hence achieves the self-sustained operation of different experiments in individual schools.

In a broader sense, the establishment of the prototype platform in this project will also serve as the standard for other interested parties (such as teachers of other science subjects) to follow. New experiment designs suitable for these subjects can be made according to their specific needs, based on the methodology of constructing the platform as laid out in this proposal. This allows the continual use of the system for educating science students in various disciplines.

Budgets

Items breakdown:

	Annual Expenses			
	Year 1	**Year 2**		**Cost**
Staffing				
Research Assistant II (Technical) (x3, 24 months) - implementation of hardware part of the platform and new experiment setups - software coding and maintenance of system - development of supporting teaching materials	$17,500 x12 x3 x1.05 (MPF) = $661,500	$661,500		$1,323,000
Student helpers (x 2, 24 months, max. 20 hours/wk for undergraduates) - assisting the technical staffs of the project	$60/hr x 20 hr/wk x 35 wks x 2 = $84,000	$84,000		$168,000
			Sub-total	**$1,491,000**
Experiment sets (only major components are listed)				
Microcontroller-Smartphone based Experiment kits:	$5040 (for 8 experiments) x 40 (set) = $201,600			201,600
Equipment to perform sensors calibration	$140,000			$140,000

Hardware and Computer Software				
Server-grade computer	$10,980			$10,980
Standalone desktops	$5,500 x 2 =$11,000			$11,000
	$110 x 40 =$4,400			$4,400
Mobile Phone	$5,000 x 4 =$20,000			$20,000
Portable Charger	$350 x 40 =$14,000			$14,000
			Sub-total	**$ 401,980**
Teaching/Knowledge transfer activities				
Supplementary teaching materials -purchasing of copyrighted items (images etc.) -editing costs -Publishing costs (web-based materials, multimedia)	$20,000	$10,000		$30,000
Training workshops (1 per year) and seminar (1 per year)(2 events per year) - Lecture materials reproduction costs (50 sets per activity)	$2,000	$2,000		$4,000
- Recruitment of student helpers for the events (6 workers per workshop, 12 hours per worker)	$60/hr x 12 hr x 6 students x 2 events = $8,640	$8,640		$17,280
			Sub-total	**$51,280**
General Expenses				
Reference books	$2,500	$2,500		$5,000
Publication and publicity - Posters, pamphlets, banners	$2,042	$6,000		$8,042
Final Report production		$2,000		$2,000
Audit Fee		$15,000		$15,000
			Sub-total	**$30,042**
Contingency				
Contingency				$14,498
			Sub-total	**$14,498**
			Project total	**$1,988,800**

Duty of Project Assistants

Project Assistant 1

Main Duties
Build up the microcontroller interface and sensors (hardware related)
Construct and design experiments
Provide technical support for schools
Assist Project leader to monitor the progress of the project
Liaise with secondary school (x2)

Qualification
A higher degree in Science, Engineering or related disciplines
Minimum 2 years of relevant work experience
Solid knowledge in technical aspects of system design and implementation
Experience in developing relevant project an advantage
Good communication, interpersonal and management skills
Good command of both written and spoken English and Chinese

Project Assistant 2
Main Duties
Build up the smartphone application for communicate between the smartphone, microcontroller and sensor
Webpage construction and maintenance
Provide technical support for schools
Liaise with secondary school (x2)

Qualification
A degree in Science, Engineering Computer Science, Computing Engineering or related disciplines
Minimum 2 years of relevant work experience
Knowledge of
At least one year's experience in mobile phone applications and web development
Experience in developing relevant project an advantage
Good communication, interpersonal and management skills
Good command of both written and spoken English and Chinese

Project Assistant 3
Main Duties
Liaise with secondary school (x6)
Assist in developing hardware/software learning packs for the project
Develop the survey and collect feedback from teachers and students.
Analysis the feedback and support the promotion activities

Qualification
A degree in Science, Engineering or related disciplines
A higher degree in Education, Sociology or related disciplines an advantage
Minimum 2 years of relevant work experience
Experience in developing relevant project an advantage
Good communication, interpersonal and management skills
Good command of both written and spoken English and Chinese

Asset Usage Plan:

Category	Item/Description	No. of Units	Total Cost	Proposed Plan for Deployment
Equipment	Microcontroller-based experiments	40	$201,600	PolyU : the platform will be maintained at PolyU so that secondary schools can continuously access the platform for teaching purpose for free
Equipment	Equipment to perform sensors calibration	1	$140,000	PolyU
Equipment	Server-grade computer	1	$10,980	PolyU
Equipment	Standalone desktops	2	$11,000	PolyU
Equipment		40	$4,400	PolyU
Equipment	Mobile Phone	4	$20,000	PolyU
Equipment	Portable Charger	40	$14,000	PolyU

Report Submission Schedule

My department commits to submit proper reports in strict accordance with the following schedule:

Project Management		**Financial Management**	
Type of Report and covering period	**Report due day**	**Type of Report and covering period**	**Report due day**
Progress Report 01/03/2018 - 31/08/2018	30/09/2018	Interim Financial Report 01/03/2018 - 31/08/2018	30/09/2018
Progress Report 01/09/2018 - 28/02/2019	31/03/2019	Interim Financial Report 01/09/2018 - 28/02/2019	31/03/2019
Progress Report 01/03/2019 - 31/08/2019	30/09/2019	Interim Financial Report 01/03/2019 - 31/08/2019	30/09/2019
Final Report 01/03/2018 - 29/02/2020	31/5/2020	Final Financial Report 01/09/2018 - 29/02/2020	31/05/2020

References:

[1] http://www.policyaddress.gov.hk/2017/eng/index.html

[2] Jong, T.D., Linn, M., Zacharia, Z.C., "Physical and Virtual Laboratories in Science and Engineering Education", Science vol. 340, Issue 6130 (2013).

[3] http://www.youtube.com/user/HongKongPolyU.

[4] M. A. Ruiz-Primo, D. Briggs, H. Iverson, R. Talbot, and L. A. Shepard, "Impact of Undergraduate Science Course Innovations on Learning," *Science,* vol. 331, pp. 1269-1270, (2011).

Appendix 1 - Sample teaching materials

All STEM learning has one thing in common – it gives students opportunities to apply the skills and knowledge they have learned. [1]

1. 目的
   (a) 創新科技是現今發展 STEM 教育的大趨勢，強調理論與實踐之間的相互作用和關係（課程發展議會, 2015, p.2）[2]。本計劃在現有初中生物科遺傳學及生物工程的課程基礎上，統整校本初中綜合科學科及生物科課程，著重對生命科學和生物科技的連貫性教育，透過生物科課程與創新科技的結合，為課程注入科普科研內容
   (b) 透過與大學科研工作者合作，深化科普科研的教學，啓發學生發展科學探究技能，推動科學的普及，並在校建立科研實驗室及透過資源開放供其他中、小學使用，以持續創新科技的發展，讓生命科學和生物科技的教育得到持續性的普及，實踐「STEM for ALL」
   (c) 結合電子教學，建立 eCourse 生物科技教育平台及 eLife 流動學習應用程式，讓學生利用相關資料作「導引式自主學習」，照顧不同能力的學生，從而提升學與教效能
2. 目標
   (a) 課程開發、調適和增潤，提升生物科課程的概念理論和應用學習之間的平衡
   (b) 學與教資源的增潤，透過科研培育計劃及實驗套件研發，讓更多學生學習和實踐生物科技前沿技術，帶動生物科技的探究，鼓勵他們將來投身科研工作
   (c) 社區夥伴協作計劃，透過中醫中藥學習活動，提供多元化的學習平台和經歷，照顧學生多樣性
   (d) 學習活動的增潤，提升學生對生物科技的興趣，培養共通能力及發揮創意潛能
   (e) 教師持續專業發展，通過不同學與教模式及課程統整、發展、交流及協作，提升教學質素
3. 對象及預期受惠人數
   全校學生約 900 人，本校、九龍樂善堂轄屬中學及其他中小學學生約 9,000 人，教師約 600 人，長者約 400 人，總受惠人數約 20, 000 人，進而推廣至全港學生、教師
4. 工作計劃
   整個計劃及活動設計共二十三個月，分為三個時段：

進行時段	內容撮要
第一時段：（11 個月） 2017 年 10 月至 2018 年 8 月 ➢ 籌備工作 ➢ 開發、整理及設計教材 ➢ 評估	搜集學習材料：擬訂中一至中三級課程內容（知識、技能和態度）、釐定及試行相關的科研實驗和制訂相關的電子教學策略和設計（包括：建立 eCourse 生物科技教育平台及錄製影片，建立 eLife 流動學習應用程式，強化「導引式自主學習」）；籌建顧中科研實驗室及顧中藥園；舉行預備工作會議；計劃和安排第二時段的執行細節、招聘及培訓教師與實驗室技術員；草擬教學進度及訂定評估準則
第二時段：（10 個月） 2018 年 9 月至 2019 年 6 月 ➢ 執行工作 ➢ 繼續設計教材及試教 ➢ 進行學習活動 ➢ 評估	舉行科研實驗教師工作坊；擬訂中四至中五級課程內容（知識、技能和態度）、釐定及試行相關的科研實驗；試教中一至中三級校本課程；運用及管理 eCourse 生物科技教育平台及 eLife 流動學習應用程式；設計及安排科研培育計劃及實驗套件研發計劃；推廣顧中科研實驗室及顧中藥園；評估及優化課程內容、科研實驗教材、相關的教學策略和進度；計劃和安排第三時段的執行細節
第三時段：（2 個月） 2019 年 7 月至 2019 年 8 月 ➢ 執行及總結工作 ➢ 後期評估 ➢ 推廣	計劃成效評估（量化和質化）：透過九龍樂善堂教育聯網的學與教資源平台及聯校品質圈，分享相關教學資源及科研實驗設計；參與及舉辦講座和工作坊，推廣至其他學校的生物科及理科教師，並普及至社區與長者學苑；透過網絡分享校本教材，將相關學習套件向全港學校推廣，將有關生物科技教育的教材上載教育城

5. 產品／成果
   生命科學及生物科技教材套（包括有關生物工程實驗活動的教材、實驗套件及電子學習套件；「導引式的自主學習模式」– eCourse 及 eLife 等）；學生在顧中科研實驗室進行實驗及對有關的實驗過程及結果進行評鑑的能力；教師及實驗室技術員進行科研實驗及有關 STEM 教育活動的能力；有關整個生物科技教育計劃的量化和質化評估；推廣與普及生物科技教育至其他中小學，甚至長者
6. 預算（總預算：$ 1,878,720）（上調至百位，即 $ 1,878,800)
   員工開支：$867,720　顧中科研實驗室工程：$120,000　實驗室設備：$710,000　顧中藥園工程：$50,000
   eCourse 及 eLife 設備及服務：$34,000　印刷、交流及協作：$77,000　一般開支：$20,000
7. 評鑑方法及準則
   夥伴大學(　　)及中小學對本校生物科技教育的策略和設計，及初中與高中課程重整後的運作狀況及成效進行評鑑，使有關計劃得以延續與普及

1 Vasquez, J.A. (2015). STEM For All: STEM – Beyond the Acronym. *Educational Leadership*, 72(4), 11-15.
2 課程發展議會 2015《推動 STEM 教育發揮創意潛能》概覽