Quality Education Fund
Application with Grant Sought Not Exceeding $200,000
Part B: Project Proposal

Project Title	**Project Number**
Developing innovative hands-on and minds-on learning and teaching packages in Physics/STEM education 創意活動教材套 - 物理科/STEM 教育	(To be assigned by the EPMS)

Basic Information

Name of School / Organisation / Individual

[redacted] Faculty of Education, The University of Hong Kong (HKU)

[redacted]

[redacted]

Beneficiaries

(a) Sector: ☐ Kindergarten ☐ Primary ☑ Secondary ☐ Special
(Please tick the appropriate box(es))

(b) Students: 2,500 (in number)* and S1-S6 (class level/age)*

(c) Teachers: 50 (in number)*

(d) Parents: Nil (in number)*

(e) Participating Schools (excluding applicant school): Nil (in number and types)*

(f) Others (please specify): Nil

** Please specify where appropriate*

Proposal

(I) Project Needs

(a) Please state the aims of the project in clear and concise terms and elaborate on how the proposed project could impact on school development.

The project aims to enhance Physics/STEM teachers' classroom teaching capacity through 4 sets of innovative hands-on and minds-on teaching and learning packages including engaging teaching models/tools, full-sets of bilingual teaching videos and manual, and inquiry-based Physics/STEM activities/projects.

(b) (i) What are the areas of the needs and priorities of the school? *(Please tick the appropriate box(es))*

☑ Enhance learning and teaching to facilitate students' knowledge on subjects / learning areas / generic skills development
☐ Promote students' social and emotional development
☐ Enhance school management / leadership and teachers' professional development / wellness
☐ Others (please specify) _____

(ii) Please give background information to justify the demonstrated needs as mentioned in (b)(i). *(Please tick the appropriate box(es))*
☐ School development plan:
☐ Survey findings:
☑ Literature review summary:
☑ Assessment on students' performance:
☑ Relevant experiences:
☑ Others (please specify)

The decline in interest in studying Science is a worldwide issue (Osborne, Simon, & Collins, 2003) and similar trend is shown in Hong Kong as reflected in the number of attending Science subjects public examinations (i.e. Physics, Chemistry and Biology) in the Hong Kong Diploma of Secondary Education Examination (HKDSE). Table 1 summarises the 2012 and 2019 HKDSE statistics.

Table 1: Number of Candidates taking HKDSE Science Subjects in 2012 and 2019
(Source: Hong Kong Examinations and Assessment Authority)

Item	2012 DSE Statistics	2019 DSE Statistics	Decreased by
Total number of candidates	73,074	56,159	23%
Biology	17,151	13,929	19%
Chemistry	17,379	13,607	22%
Physics	15,491	11,283	27%

The drop in the number of Physics candidates is alarming because it may potentially reduce the qualified people to peruse Science-related careers which, in turn, would be harmful to the policy in advocating STEM Education both in Hong Kong and around the world as well as to the global economy.

Teaching and learning in Physics has long been challenging because it involves a lot of abstract concepts and this contributed to the loss of academic efficacy, interest and enjoyment (Klopfer, 1971; Osborne et al., 2003). To facilitate students' academic efficacy and promote learning interest, Bransford, Brown, and Cocking (2000) encouraged teachers to use different means to uncover and address students' pre-exist concepts before they engage the new concepts. Although e-learning such as simulations and e-books are recommended to assist conceptual understanding in Physics, learning is indispensable with body and enactment particularly to the kinesthetic learners. In fact, learning with hands-on and minds-on activities in which "students manipulate and observe real objects and materials" has long been encouraged in Science education (Abrahams & Millar, 2008, p. 1945).

Having informed by the literature and/or students' performance in the local assessments such as HKDSE, challenges of students' conceptual learning are identified. As such, this project aims at developing innovative hands-on and minds-on learning and teaching packages which include interactive teaching models and tools, full-sets of bilingual teaching videos and manual, inquiry-based Physics/STEM activities/projects, for dissemination to the in-service Physics/STEM teachers in secondary schools. For instance, to address the problems in constructing free body diagram reported in 2015 HKDSE (Q4c), an interacting 3D printed teaching model and inquiry-based activities were designed, as shown in Exemplar 1 on P.2-3.

(c) Please elaborate on the innovative ideas or new practices to enhance, adapt, complement and/or supplement the existing practices that will facilities the development of the school to address the needs specific to its own context.

Teaching and learning in Physics has long been challenging because it involves a lot of abstract concepts. Having literature reviewed and/or students' performance studied in local assessments, 4 sets of innovative

hands-on and minds-on teaching and learning packages will be developed in this project to address the learning challenges. The innovative ideas and practices are threefold.

First, the teaching and learning packages are learners' needs driven. It will address the learning challenges and provides interactive teaching models/tools together with full-sets of bilingual teaching videos and manual to foster academic efficacy. Second, inquiry-based Physics/STEM activities/projects with bilingual worksheets will be included which promotes students' learning interest. Third, the design and practices are not only learner-driven and interactive, but also feasible, low-cost and easy to replicate in the local school context.

The applicant has collaborated with the HKEdCity since 2018 in developing similar teaching and learning packages for adoption by Physics/STEM in-service teachers and students. The six teaching and learning packages developed can be downloaded from the HKEdCity website for free. Two exemplars are given below to illustrate the innovative ideas and practices.

Exemplar 1: Free-body Box

To focus on students' poor performance of free body diagram construction (Fig. 1), a self-designed 3D printed teaching model/tool and an inquiry-based activity teaching package was developed, which can be downloaded from the HKEdCity: https://resources.hkedcity.net/resource_detail.php?rid=755263439. Screenshots of the resources are shown in Figs. 2-4 below.

Fig. 1: Sample of Student's Performance in 2015 HKDSE Question 4(c)
(Source: Hong Kong Examinations and Assessment Authority http://www.hkeaa.edu.hk/en/hkdse/hkdse_subj.html?A2&2&20_25)

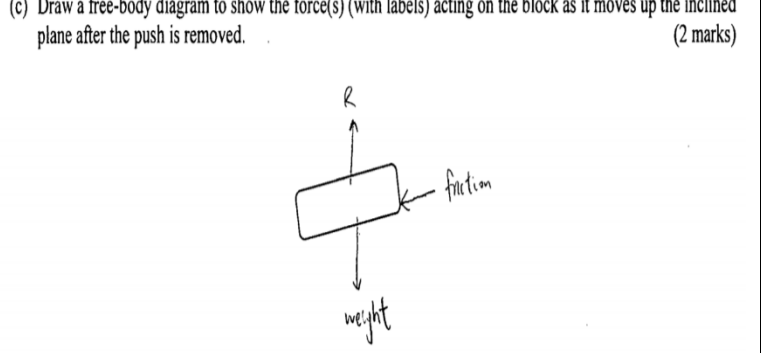


Fig. 2: Learning and Teaching Package – Free-body Box

Fig. 3: 3D Teaching Model (in stl file)

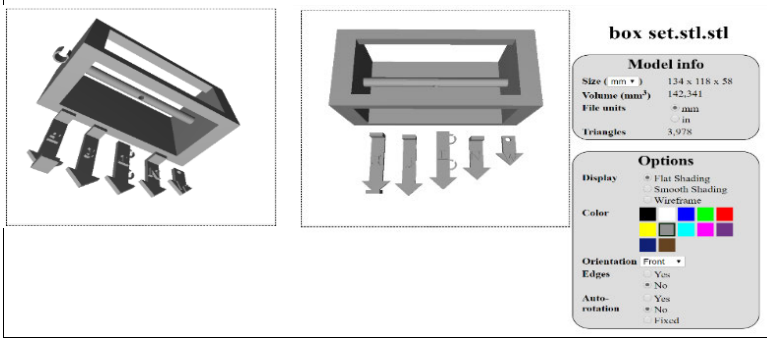
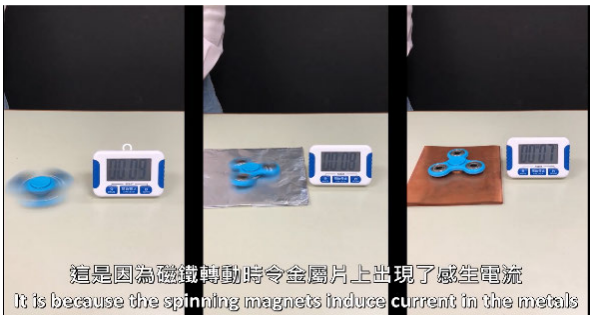


Fig. 4: 3D Teaching Model Prototype

Exemplar 2: Fidget Spinner Experiment

To tackle students' alternate conception of eddy current formation, an interactive teaching model was built and an inquiry-based learning and teaching package was developed, which is available on the HKEdCity website: https://resources.hkedcity.net/resource_detail.php?rid=346636743. Screenshots of the resources are shown in Figs. 5-7 below.

Fig. 5: Learning and Teaching Package – Fidget Spinner Experiment

Fig. 6: Bilingual User Video	Fig. 7: Inquiry-based Experiment
	

(II) Project Feasibility

(a) Please describe the design of the project, including:

(i) Approach/Design/Activity (Applicants are advised to provide details on project activities as well as learning and teaching arrangements.)

This project is a collaboration work with BEd&BSc and PDGE Physics major students in the Faculty of Education, HKU. They will serve as part-time student research assistants/part-time research assistants in co-constructing the innovative teaching packages. Two workshops will be organised for dissemination to the in-service Physics/STEM teachers afterwards.

A similar dissemination was organised in 2018-19, titled "Learning and Teaching Strategies Series: Dissemination of Teaching Package on Physics-related Activities" (CDI020190864) which was organised by Curriculum Development Institute (CDI). Below was the EDB's Training Calendar System for reference.
https://tcs.edb.gov.hk/tcs/admin/courses/previewCourse/forPortal.htm?courseId=CDI020190864&lang=en

(ii) Key Implementation Details

Project period: July 2020 to September 2021

Month / Year	Content / Activity / Event	Target Beneficiary / Participants
Jul 2020 - Nov 2020 (5 months)	Stage 1 ● Recruitment of project staff, procurement of required equipment such as 3D printer and ScanNcut machine ● Formulation of project ideas (S1-S3 Science topics, HKDSE Physics topics or S1-S6 STEM topics): Literature review of education journals, local assessment (HKDSE), large-scale global assessments (PISA/TIMSS), and/or consultation of in-service teachers	

Dec 2020 - Jul 2021 (8 months)	Stage 2 ● Development of 4 sets of innovative hands-on and minds-on teaching packages: designing and building prototypes of the engaging teaching models/tools, full-sets of bilingual video clips and manual, inquiry-based Physics/STEM activities/ projects ● Preparation of teaching and learning packages for dissemination workshops ● Organisation of two half-day workshops on teaching package dissemination	50 in-service Physics/STEM teachers, 2,500 students (50 students per school)
Aug 2021 - Sep 2021 (2 months)	Stage 3 ● Fine-tuning of the 4 sets of teaching packages ● Dissemination of the 4 sets of teaching packages to all local secondary schools through HKEdCity Resources Repository ● Preparation of the project report	All Physics/STEM teachers and students studying Physics/STEM education

(b) Please explain the extent of teachers' and/or principal's involvement and their roles in the project.

(i) Number of teachers involved and degree of input (time, types, etc.):
1 Senior Lecturer in the Faculty of Education, HKU

(ii) Roles of teachers in the project: *(Please tick the appropriate box(es))*

☑ Leader ☐ Co-ordinator
☑ Developer ☐ Service recipient
☐ Others (please specify)

(c) Please provide the budget of the project and justify the major items involved.

Grant sought: HK$ $199,830

Budget Item*	**Expenditure Detail (Including the breakdown for the budget items)**		**Justifications**
	Item	**Amount**	
i) Staff	1. Part-time Research Assistants	$27,216 [$108/hr x 60 hrs + 5% MPF x 4 vacancies]	Part-time research assistants with at least a relevant Bachelor's degree and relevant experience will be recruited to support the project, e.g. design of the learning and teaching activities, models and tools, contents of the videos, etc.
	2. Part-time Student Research Assistants	$85,176 [$60/hr x 338 hrs + 5% MPF x 4 vacancies]	Current undergraduate students of a relevant discipline will be recruited to serve as part-time student research assistants to support the project, e.g. video-shooting and post-production, translation, production of prototypes, models/tools for the packages, logistics support for the workshops etc.
iii) Equipment	1. 3D Printer (4MAX Pro)	$5,800	3D Printer for production of prototypes, models/tools.
	2. ScanNcut	$4,000	Electronic die cutting machine with built-in scanner for production of prototypes, models/tools.
iv) General expenses	1. PLA filament for 3D Printer	$3,600	Materials for the 3D Printer for production of prototypes, models/tools.
	2. Materials for ScanNcut	$15,000	Materials for the ScanNcut for production of prototypes, models/tools.

	3. Printing and Production of Packages (100 sets)	$20,000	100 sets of hardcopies of the packages, including models/tools and videos will be prepared for distribution in the dissemination workshops.
	4. Miscellaneous	$3,500	For stationery, postage, photocopying, printing, etc.
	5. Classroom rental for the two workshops	$3,040	[$380 x 4 hrs x 2 workshops] Including one extra hour for set up and wrap up for each 3-hour workshop
	6. Audit fee	$5,000	
	7. Standard indirect overhead charges imposed by the University (15% of Total Cost)	$25,850	As a Government-subvented institution, it is the policy of the University to levy overhead charges on all non-UGC-funded activities, to ensure that University Grants Committee (UGC) funds are not utilised in funding of non-UGC-funded activities.
v) Contingency	3% of total costs of equipment and general experiences	$1,648	For items 1-2 under (iii) Equipment and items 1-5 under (iv) General expenses
	Total Grant Sought ($):	**$199,830**	

** Please cross out as appropriate*

(III) <u>Expected Project Outcomes</u>

(i) Please describe how to evaluate the effectiveness of the project. *(Please tick the appropriate box(es))*

- ☐ Observation:
- ☐ Focused group interviews:
- ☐ Pre- and post-activity surveys:
- ☐ Performance change of students in assessment:
- ☒ Others (please specify) Questionnaire will be administered to evaluate the effectiveness of the dissemination workshops as well as the teaching and learning packages

(ii) Please state the project deliverables or outcomes. *(Please tick the appropriate box(es))*

- ☑ Learning and teaching materials
- ☑ Resource package
- ☐ DVD
- ☑ Others (please specify)

Tangible outcomes include:

- Two 3-hour dissemination workshops each for 25 Physics/STEM teachers (i.e. 50 Physics/STEM teachers in total)
- 4 sets of innovative hands-on and minds-on teaching and learning packages including engaging teaching models/tools, full-sets of bilingual teaching videos and manual, inquiry-based activities/projects
- 100 sets of hardcopies of the packages will be distributed to participants of the dissemination workshops
- The packages will be uploaded to HKEdCity for all Physics/STEM teachers and students to use (free downloading)

Intangible outcomes include (i.e. impact on learning):

- Teachers' competence in addressing students' learning challenges will be enhanced
- Student learning experiences and interest in Physics/STEM will be promoted

References:

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn* (Vol. 11): Washington, DC: National academy press.

Klopfer, L. E. (1971). *Evaluation of learning in science*: McGraw.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079.