Quality Education Fund
Application with Grant Sought Not Exceeding $150,000
Application Form --- Part II: Project Proposal

Project Title	**Project Number**
To Develop Teaching Aids for Self-Paced Learning of Physics-Related topics using 3-D printers 活用3D打印:< 開發物理科相關之循序式自學教材>	2016/0255 (Revised)

Basic Information

Beneficiaries

(a) Sector: ☒ Secondary

(b) Students: 100 (in number) and S4 – S5 (class level/age)

Proposal

(I) Project Needs

(a) Please state the aims of the project in clear and concise terms.

1) To develop STEM teaching aids based on 3-D printers for high school teachers.
2) To establish students' skills in basic scientific tools pertinent to physics learning through 3-D printer.
3) To enhance students' as well as teachers' competence with the use of 3-D printers as applied in science problems.

(b) (i) What are the areas of the needs and priorities of the school?

☒ Enhance learning and teaching to facilitate students' knowledge on subjects / learning areas / generic skills development

☒ Others: Fully utilize the existing teaching equipment (in particular, 3-D printers) in secondary school for teaching and learning purpose.

(ii) Please give background information to justify the demonstrated needs as mentioned in (b)(i).

☒ Survey findings: Interviews with physics teachers in secondary schools have illustrated widespread issues concerning the implementation of problem base learning (PBL) in secondary school. To deal with this PBL issue, some secondary schools have purchased 3-D printer for the students to develop projects utilizing custom-made components. However, there is the issue of incorporating the technology in the curriculum and/or individual projects in the most meaningful way. If 3D printing is to be included in the curriculum, the teachers need to understand its operations as well as adequate supports such as relevant learning materials. This categorically demands high quality, upfront training and planning, together with ongoing technical support. In this way, teachers will be benefited from the well-developed teaching aids, and as a result the 3-D printing can substantially help the teaching and learning of the students.

☒ Literature review summary: There is increasing interests in using 3-D printers for teaching and learning purpose, especially for high school students. (www.learn. . com; www. .com; www. .com; www. .com). Educators have adopted the developed packages to facilitate the learning of students, both inside and outside classrooms. However, the teaching materials on the internet are diversified (with topics ranging from arts, home economics to science) and target primarily at syllabi outside Hong Kong (mainly US and Europe). This is of paramount important for local physics teachers to have appropriate teaching aids tailor-made for DSE curriculum.

☒ Relevant experiences:

1. The Department of Applied Physics (AP) in PolyU provides physics teaching for 1st year undergraduate students in science and engineering-discipline, and has gathered experiences in the shortcoming of students in terms of experimental technique and critical thinking for solving physics problems.
2. Three QEF teaching projects (ref. Nos. 2013/0127, 2014/0600 and 2014/0761) have been launched by the team members starting Sep 2014. In these projects, collaboration between local high schools and our team members were in good conditions. The team members have the necessary technical knowledge and scientific instrumentation experiences in developing teaching aids proposed here. The local high school teachers will help us to deliver the teaching aids for trial run in their schools. They will give us feedback on the performance of the teaching aids.

(c) Please elaborate the innovative ideas or new practices to enhance, adapt, complement and/or supplement the existing practices of the school.

While the majority of physics teaching in secondary schools focus on the covering of physical phenomena as prescribed in the syllabus, many subtle, fundamental and interesting scientific concepts with daily application examples could not be demonstrated in the classes. Given the hectic learning pace of DSE students, many teachers have difficulty to spare the class time for such practices. To disentangle this problem, 3-D printer will be a possible answer. From elementary to university classrooms, 3D printers for schools are helping students find new ways for engaging students with learning material. Whether it is home economics, physics or history, teachers are discovering that 3D printers provide new and novel learning opportunities that increase confidence and engage students' imaginations. In terms of critical thinking, 3D printers for schools are changing the paradigm; empowering students to create physical objects that solve problems using reasoning and logic. It sets the tone for experimentation, success, failure, and learning that transcends paper, video, or white boards through observation and problem solving within the physical world rather than on paper. With 3D printing as the foundation for STEM learning, students have the resources to re-engineer the world. It improves dedication among students, teamwork, and troubleshooting which will help in their STEM future.

However, there is the issue of embedding the technology into the DSE curriculum and/or school based individual projects in the most meaningful way. Before including the 3D printing into the curriculum, school teachers need to understand its operations and adequate learning materials to support their teaching. This categorically demands high quality, upfront training and planning, and ongoing technical support. However, these kinds of assistance for local high school teachers are missing. Our aim is to design 3-D printer teaching aids by developing learning materials for selected physics topics pertinent to physics learning, including center of mass, mechanics, Archimedes' Principle and component transforming mobile phone into spectrometer. By developing relevant L&T materials with short video clips for each designed topic, both teachers and students can use 3-D printers to develop their own design in a self-paced and progressive manner i.e. student-center learning. Lesson plans and practical examples for flipped-classroom exercises will also be designed for secondary school teachers, with the goal of maximizing the impact of the experience on the learning of students. Materials designed will closely align with the context of the local physics education by quoting examples related to DSE physics syllabus. In this project, both Chinese and English versions of materials will be produced to fit the needs of students in Hong Kong.

(II) Project Feasibility

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

(i) Approach/Design/Activity

There are countless paths to choose from when incorporating 3D printing with STEM education in high schools. For example, students learning engineering related topics may be best suited to form their own design groups; taking their product from concept to prototype with teaching assistance. Interested in a science project on robotics? Using 3-D printers, students can print arm components instead of purchasing them from suppliers or hardware stores. Looking to demonstrate wind power during science class? Student can create a miniaturized 3D printed fan assembly for demonstration. Students can bring the universe to classroom by fabricating entire solar systems, planets, suns, and stars for decoration. In Physics class, the students calculate center of mass, and then design toy figures accordingly that could balance on a finger without falling over. Afterwards, students turn to computer aided design (CAD) programs to create models of the figures in question, and the models are turned into real-life figures using a combination of the 3D printer and what can be referred to as " Bricks." The students then set out to balance the figures on a finger. With each student turning to a different figure—everything from rocket to mice—the end result will be a wildly creative affair that has a serious mathematical underbelly hanks to the use of center of mass computations. These are difficult by most any reckoning, especially so for high school students.

Before including the 3D printing into the curriculum, a well-designed high quality teaching aids with upfront training and technical support for teachers will be of paramount important. The main objective for this proposed project will be to develop high quality teaching aids for local high school teachers in order to assist their teaching using 3-D printers. Supplemented by developed teaching aids including teaching examples, design of apparatus, demonstration video clips, and manual as well as instructions, teachers can use these aids in developing different school based projects for students to perform self-paced learning outside classroom via 3-D printers, in a way reminiscent to the 'flipped classroom' practice. The upcoming trend of student self-learning and flipped classroom practice as well as PBL mode provides new opportunities in fortifying students of better learning environment.

A. Design of Materials

(1) Simple background materials notes on selected topics will be developed, familiarizing students of the problems to be covered. A simple user guide of the video will also be provided to teachers as reference. Such materials can also be used as supplementary information to assist in the teaching activities.

(2) Short tutorials clips (less than 10 min each) will be produced. Main topics will be carefully designed and segmented into small units. The proposed main topics are closely correlation with different physics topics and are listed as follows:

Proposed Topics#	Suggested topics for investigative base learning
Center of mass	Find the center of mass of different shapes.
Spectrometer for mobile phone	Use the developed spectrometer to measure the light spectrum of night pollution.
Wind blades for Wind turbine	What is the effect of the blades on the efficiency of the wind turbine?
Disc of different sizes and shapes	To demonstrate the working principle of acoustic mirror.
Pots of different shapes	To investigate Archimedes' Principle.

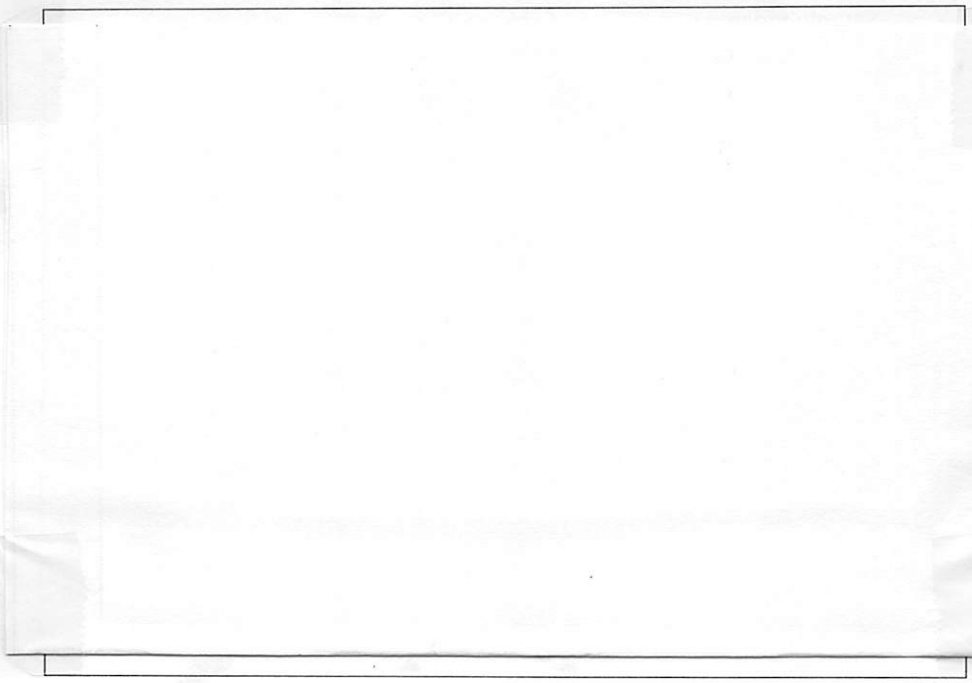
Five topics will be covered when the project is completed. Each topic will have a video in English and a video in Chinese for secondary schools with different medium of instruction.

In each video clip, a short introduction of the selected concepts or ideas (~ 1-2 mins) then followed by the explanation on main concepts (~ 3-4 mins). A step-by-step demonstration on the design (~ 3-6 mins) which is correlated the physics topics with daily life application. This practice ensures students to learn the topics in a progressive manner, and the teachers could tune the pace of learning by viewing (and reviewing) the clips according to their needs and schedules.

Supplementary teaching aids will be developed in each topic, including teaching examples, design of apparatus and manual.

Sample video
The video will be divided into 3 parts:
(1) Introduction (about 1-2 mins)
(2) Main Content (about 3-4 mins)
(3) Activities (about 3-6 mins)

The following sample video is based on "Center of mass"



This practice ensures students to learn the topics in a progressive manner, and the teachers could tune the pace of learning by viewing (and reviewing) the clips according to their needs and schedules.

Sample questions (3-4 questions, in either multiple choices or short question format) will be provided to teacher and teacher could select a part of the questions as take-home exercise(s). Student could complete the questions based on the investigation of the 3D printing product and the related activities.

Teacher training:
Before the pilot run of the project, project team will organize a 1.5 hour mini-workshop for teacher in collaboration schools which will be held in PolyU. The aims and the expected learning outcome of this project will be introduced. Project Assistant will demonstrate the workflow for preparing the 3D printing product. The related teaching materials and the final product of the 3D printing will be provided to teachers for in-class demonstration. Our project assistant will provide technical assistance to teacher on the 3D printing issue. Teacher can modify the suggested teaching materials provided by project team according to their needs which have a higher flexibility for implementation.

Collaboration with school teachers:
Teachers can make use of the provided materials for developing a school based projects for students to perform self-paced learning outside classroom via 3-D printers. The learning outcome of the students will be assessed by teachers accordingly. An online user's experience survey will be given to the project participants (both teachers and students) to collect their feedback. The content of the materials will be modified based on the feedback.

Outcome measurements:
a) feedback from students and teachers;
b) interviews

Month / Year	Content / Activity / Event	Target Beneficiary/Participants
Sep 2017 – Feb 2018	- Development of written L&T materials. - Production of video clips - Production of website	Project team members
Mar 2018 – May 2018	- Pilot run of sample L&T materials and video clips - Collection of feedback from teachers and students via online survey	Physics Teachers of participating schools and project team members
Jun 2018 –	- Sharing session with users Collection of feedback from teachers and students via online survey - Modification of materials and website	Physics teachers of participating schools and project team members
Jul 2018 – Aug 2018	- Re-run of L&T materials and video clips after modification	Physics teachers of participating schools and project team members
Sep 2018	- Finalizing materials on the website - Analysis of student exam results - Evaluation of project	Physics teachers of participating schools and project team members

(3) To enhance the impact on the students, worked examples will be prepared and distributed to teachers, alongside with suggested teaching plans. Teachers will be recommended with methodologies of conducing the learning for their students, following the concept of 'flipped-classroom' practices. Both English and Cantonese versions of the videos will be prepared to facilitate student learning with different media of instructions. All the information will be presented in the form of a website.

(4) A project assistant will be recruited in this project. The qualification of project assistant should have either a higher degree in science discipline with 1 year working experience; or a recognized degree in science disciplines with 2 to 3 years working experience. The project assistant is responsible for developing the learning materials and videos. He/she will liaise with physics teachers and team members. He/ She will develop the survey and collect feedback from teachers and students.

(5) The ownership and the copyright of the deliverables are vested in the Grantor.

C. Activities

(1) *Pilot run of sample modules*. To familiarize participating school teachers with the use of the videos and flipped-classroom practices, a pilot run will be conducted on a sample module with the help of some core members from secondary schools. This allows the team to anticipate the potential issues with the exercise and make relevant changes to the materials. This is to be conducted in Mar 2018.

(2) *Launching of modules for all participating schools*. After the pilot run and modification of materials, a full-scale launching of all modules will be conducted from Jun 2018 to Jul 2018. At the end of exercise, survey forms will be distributed to students to collect their opinions on the practice.

(3) *Post-activity sharing session*. A sharing session will be organized to collect teachers' experience over this project, and the potential future development of the practice arising from this project.

(ii) Key Implementation Details

Project period: 9/2017 to 9 /2018

(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.):

- Physics teachers or related teachers.
- Co-planning with project team before the pilot run stage.
- Make use of the teaching materials with students and have classroom observation. Assess the learning outcome of students.
- Provide feedback.

(ii) Roles of teachers in the project:

☒ Leader ☒ Co-ordinator

☒ Developer ☒ Service recipient

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

Grant Sought: HK$ 149,600

Budget item	**Expenditure Detail**		**Justification**
	Item	**Amount ($)**	
Staff	1 Project Assistant	$ 15,300 x 1.05 x 9 months = $ 144,585	The personnel involved will assist the project team members to produce teaching materials and video clips for the project.
General expenses	Audit fee	$5,000	For project auditing.
Total Grant Sought ($):		$149,600	

(III) Expected Project Outcomes

(i) Please describe how to evaluate the effectiveness of the project;

☒ Focused group interviews: Interviews will be conducted on participating physics teachers and selected groups of students, gathering their opinions on the project and the impact on student physics learning in general.

☒ Pre- and post-activity surveys: Questionnaires will be issued for both students and participating teachers, to collect their opinions on the use of such a teaching means for learning physics.

The success criteria to measure/assess the achievement/attainment of the project aims/objectives are based on the online feedback survey from teachers and students if 70% of teachers agree this project can enhance students' learning experience in Physics 70% of students agree this project can enhance their learning experience in Physics

and (ii) Please state the project deliverables or outcomes.

☒ Learning and teaching materials

☒ Others: A website which hosts all the materials prepared in the project, including (1) L&T materials, (2) video clips, (3) suggestions on adopting the materials in physics teaching, and (4) post-activity questionnaires for collecting users' opinions about the platform and their confidence in tackling various topics.

Report Submission Schedule

My school commit(s) to submit proper reports in strict accordance with the following schedule:

Project Management		**Financial Management**	
Type of report and covering period	Report due date	Type of report and covering period	Report due date
Progress Report 1/9/2017 – 31/8/2018	30/9/2018	Interim Financial Report 1/9/2017 – 31/8/2018	30/9/2018
Final Report 1/9/2017 – 30/9/2018	31/12/2018	Final Financial Report 1/9/2018 – 30/9/2018	31/12/2018