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Developing a New Curriculum for STEM Education for Secondary Students

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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Short Research Article

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ABSTRACT

In Hong Kong, STEM (Science, Technology and Mathematics Education) education was promoted since 2015. After proposed in the same year's Policy Address, the Education Bureau (EDB) would renew and enrich the curricula and learning activities of the Science, Technology and Mathematics Key Learning Areas, and enhances the training of teachers, thereby allowing primary and secondary students to fully unleash their potential in innovation. STEM programme aims to better prepare Hong Kong students for the rapid economic, scientific and technological developments ahead, and STEM education is being promoted as a key emphasis in the ongoing renewal of the school curriculum that is essential for their lifelong learning and whole-person development. According to the information provided by the STEM Education service provider, each participant is charged around HK$600 to $3000 for the STEM workshop. As a result, we estimate that more than 50 million will be spent in the STEM Education-related business.

Through this study, the project team aims to a) review and summarise the current STEM curriculums in Hong Kong, b) design and implement a curriculum of STEM education for secondary school, c) conduct workshop for the new curriculum and invite students to take part, and d) measure the effectiveness of STEM by survey.

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1. INTRODUCTION

In the curriculum context of Hong Kong, STEM education is promoted through Science, Technology and Mathematics Education. Apart from cultivating students' interest in Science, Technology and Mathematics, and developing among them a solid knowledge base, STEM education aims to strengthen students' ability to integrate and apply knowledge and skills across different STEM disciplines, and to nurture their creativity, collaboration and problem solving skills, as well as to foster their innovation and entrepreneurial spirit as required in the 21st century. Through the promotion of STEM education in schools, the EDB aims to nurture a versatile pool of talents with different sets and levels of skills to enhance the competitiveness of Hong Kong.

In promoting STEM education, references have been made to the strategies and measures of other countries/regions for their promotion of STEM education. The Education Bureau of Government of HKSAR [1] launched a consultation from early November 2015 to early January 2016 on promoting STEM education to collect views and suggestions on the aims, objectives and proposed strategies related to the promotion of STEM education in local primary and secondary schools. The consultation document [2], namely "Promotion of STEM Education –Unleashing Potential in Innovation" was released in November 2015 to introduce the proposed strategies above. Two symposia cum consultation sessions have been organised to solicit initial views from school principals and teachers. Separate consultation sessions have also been held for different STEM-related KLAs and the related curricula. In addition, focus group meetings have been arranged for relevant stakeholders. According to the report, the general feedback collected from consultation sessions, meetings and other channels about the initiative to promote STEM education in schools is positive and encouraging.

To facilitate the promotion of STEM education in secondary schools, according to theGovernment of the HKSAR [3], the EDB has disbursed a one-off grant for the promotion of STEM education to all government secondary schools, in March 2016. The amount of the grant was HK$200,000 per school. With the extra funding and strong promotion from the EDB, many schools include STEM education in their extra curriculum activity. According to the information provided by STEM Education service provider, each participant is charged around HK$600 to $3000 for the STEM workshop. As a result, we estimate that more than 50 million will be spent in the STEM Education-related business.

Zhang [4] mentions that one of the reasons for students to have poor mathematics performance is that they are lack of interest in learning mathematics, and some even reported that they do not like learning mathematics. How to encourage students' interest has become a considerable concern for teachers and parents. Cornell [5] explains that mathematics subjects in school are sometimes sources of frustration and failure to children. Cornell argues that repeated skill-and-drill exercises cannot effectively help them understand the rationale behind calculations, and it would increase children's mathematics anxiety, which may subsequently affect how they perceive their mathematics and science ability [6]. Köller et al. [7] report the positive correlation between children's learning interest and their mathematics achievement from their findings. However, it is noteworthy that they also emphasise that highly structured instructions such as written examinations will not improve students' motivation for learning mathematics. Therefore, carefully designed teaching materials play a significant role in cultivating children's interest in learning mathematics and science. Zhang [4] reminds that mathematics and science learning materials "should be designed based on sound learning theories" and relevant to their learning context (p.255). Along with this line of thought, to arouse students' interest in learning, the design of mathematics and science learning materials should be interesting and in students' point of view.

Freeman et al. [8] suggested that the effectiveness of STEM Education under the current curriculum in Hong Kong was not being studied and examined at this stage. Since the EDB proposes to conduct research and evaluation studies on the implementation of STEM education at school level, this project aims to examine the effectiveness of current curriculum of STEM, design and implement a curriculum of STEM education for secondary school.

In this study, the project team aims to a) review and summarise the current STEM curriculums in

Hong Kong, b) design and implement a curriculum of STEM education for secondary school, c) conduct workshop for the new curriculum and invite students to take part, and d) measure the effectiveness of STEM by survey.

2. METHODOLOGY

Review and Summarise the Current STEM Curriculums in Hong Kong: The project team will first review and summarise the current existing STEM curriculums. A questionnaire will be developed and sent to secondary school teachers. The questionnaire aims to collect all the opinion from teachers and analyse if the existing curriculums achieve the designed objectives set by the EDB.

Design and Implement a Curriculum of STEM Education for Secondary School: After collecting the feedback from secondary school teachers, the project team will develop a new curriculum. One workshop and one competition were carried out for no less than 150 secondary school students. After that, an individual interview with students and teachers were carried out. No less than fifty student participants and twenty teachers were invited for a one-to-one and face-to-face interview.

All interviews were conducted in a semi-structured way. Each interviewee was asked the same pre-determined questions. However, follow-up questions were further asked based on the responses. The interview aims to solicit students' perceptions of the usefulness and effectiveness of STEM education, as well as the effectiveness of the new curriculum.

2.1 Review and Summarise the Current STEM Curriculums in Hong Kong

In Hong Kong, the promotion of STEM education was first proposed in the 2015 Policy Address and further supported in the 2016 Policy Address. It aims to develop students to become lifelong learners of science, technology and mathematics so that they can meet the challenges of the 21st century, and to help nurture versatile talents in STEM-related areas to enhance the development of Hong Kong. Since the promotion from HK Government, STEM education also became a business in Hong Kong. After reviewing the current Hong Kong STEM education parties, most of the curriculums promoting the robot creation and development programme. Our team checked 52 popular STEM education curriculums in Hong Kong in early 2018. The following table shows the most common education kit sets that are used in Hong Kong (Table 1).

Table 1. 52 popular STEM education curriculums in Hong Kong

STEM education curriculums	*Number*
Lego Mindstorms Education Base Set (EV3)	18
mBot V1.1 STEM Educational Robot Kit	21
Ubtech Jimu Mini Kits	5
Others	8

3. RESULTS

After identifying the most common used kit sets in Hong Kong. Our developed two similar curriculums for the Lego Mindstorms Education Base Set and Makeblock mBot. Thirty students from six secondary schools were invited and take part in the training course. None of the selected students have any experience in using Lego Mindstorms Education Base Set and Makeblock mBot, and reported had other learning experience in robot development as well. Selected students are required to take part in a three hours workshop for each of the education kits. After two days workshop, students need to complete a task by using both Lego Mindstorms Education Base Set and Makeblock mBot.

After all the tasks, thirty students and six teachers were invited for face-to-face, one-to-one interviews. All interviews were conducted in a semi-structured way. Each interviewee was asked the same pre-determined questions; however, additional questions were also asked based on students' responses. Out of our expectation, 80% of students prefer using Lego Mindstorms Education Base Set instead of Makeblock mBot. More than 60% of students suggested that Lego Mindstorms Education Base Set is more complicated but more powerful than Makeblock mBot. However, all six teachers represented that Makeblock mBot is more suitable in secondary school education as it is much cheaper than Lego Mindstorms Education Base Set. Furthermore, given the tight daily teaching schedule, that is too complicated to learn Lego Mindstorms Education Base in a short period of time.

Table 2. Lego EV3 learning programme

Course Structure

- EV3 Software Overview
- EV3 Basic Programming Concept and Simple Function (Loop, Switch and Wait)
- Programming with EV3 Main Unit
- Programming with EV3 Motor Blocks (Move Steering / Move Tank)
- Programming with EV3 Touch Sensor
- Programming with EV3 Color Sensor
- Programming with EV3 Ultrasonic Sensor

Basic Labs (30 mins to 45 mins each)

- Play the image and sound with EV3 main unit when pressing the touch sensor.
- Count and display the number of pressing a touch sensor and adjust the sound volume when the count is increasing.
- Build a car for basic driving (move forward, move backward, 360-degree rotation etc.).
- Build a car with a color sensor to detect the line on the floor and stop/move backward.
- Build a car with a touch sensor as control for move forward.
- Build a car with an ultrasonic sensor to detect the wall and stop/move backward.

Challenge Labs (Optional without instruction)

- Design and build a game with two touch sensors. Use EV3 to determine who press the touch sensor first and play the image/sound for the winning team.
- Design and build a car to race on a square path.
- Design and build a car with an ultrasonic sensor to run exit the maze/bypass the road block.

4. DISCUSSION

After identified the preference from sampled students and teachers, our team developed and suggested a Lego EV3 learning programme for the students. The detail of the programme was listed above (Table 2). The following programme will further applied to new students and testing the effectiveness.

5. CONCLUSION

A similar objective based curriculum for the most commonly used kit Lego Mindstorms Education Base Set was successfully developed for Hong Kong secondary school. After an intensive workshop for thirty non-experienced students, face-to-face interviews were carried out for both students and teacher. By the founding of this project, we would like to understand the comments from the students and the point of view from current education parties. The results will further applied to the next stage curriculum development of Hong Kong STEM education.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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