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Promotion of STEM Education in Vocational and Professional Education and Training (VPET)

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Abstract

Vocational and Professional Education and Training (VPET) enhances learners to acquire professional knowledge, apply practical skills and develop positive workplace attitudes to support the long-term development of a country or a city. Established in 1982, the Vocational Training Council (VTC) is the largest vocational and professional education and training provider (VTC 2016) in Hong Kong. Through a wide range of pre-employment and in-service programmes, it establishes valuable credentials for approximately 250,000 students each year with internationally recognised qualifications. As a member institution of VTC, the Hong Kong Institute of Vocational Education (IVE) offers full-time and part-time programmes - covering an array of disciplines and at levels ranging from higher diploma to certificate - nurturing talents valued by industries.

STEM (Wikipedia 2016), an acronym that refers to the academic disciplines of Science, Technology, Engineering and Mathematics. STEM (Education Bureau, Hong Kong 2015) plays a pivotal role in educating students to meet the rapid changes and continuous challenges in our society and all over the world due to swift economic, scientific and technological developments. In alignment with this worldwide trend in education, the promotion of STEM in VPET, especially in the Applied Science (AS), Engineering (ENG) and Information Technology (IT) Disciplines, has been the major focus of development in VTC for years.

In this paper, various STEM education strategies under VTC will be addressed. One important milestone is the setup of STEM Education Centre to serve as a platform for cross-disciplinary projects for STEM students and to promote STEM education to the public and primary/secondary school students through seminars, workshops and international events.

Pertaining to the internationalisation of vocational and professional education, the implementation of exchange programmes in STEM study with overseas countries, local students and their counterparts is another strategic development of VTC. It broadens students' horizon and generates their inspirations in team work and

collaboration projects. The Engineering Discipline in IVE has completed a number of successful workshops with MIT (Massachusetts Institute of Technology) students, in which IVE students were inspired to explore their learning, employing different learning methods and have gained insights into the development of STEM industries, as well as interests in STEM subjects.

In June 2016, as another important event to internationalise VPET, VTC organised an international STEM Students Forum in the WorldDidac Asia in Hong Kong. This provided a golden opportunity for the local and overseas students from Australia, UK and Singapore to exchange a wealth of information from different perspectives in STEM education. A similar international STEM forum is underway for 2017 covering sessions with outstanding STEM projects from academic institutions, to study STEM teaching and learning pedagogy, and to look into the STEM project development with VTC students.

Other strategies such as Science and Mathematics Help Desk, Technology Enhanced Learning and Teacher Support will also be discussed in the paper.

Keywords: STEM Education, VPET, International Exchange, Technology Enhanced Learning, Multiple Institutions Collaboration.

Introduction

The HKSAR Government will step up efforts to promote STEM education and encourage students to pursue the study of these subjects as addressed by the Chief Executive of the HKSAR. (Policy Address 2016) The Curriculum Development Council under the Education Bureau of Hong Kong (Education Bureau, Hong Kong 2015) developed strategies for promotion of STEM education among schools in Hong Kong.

Hong Kong students performed well in Science and Mathematics over the years as revealed from international studies and competitions. However, integration of STEM subjects and enhancement of hands-on activities in schools are important to strengthen the ability of students to solve daily life problems with practical solutions and innovative designs. Throughout these activities, it can nurture

students' creativity, collaboration and problem solving skills, as well as to foster their innovation and entrepreneurial spirit in the 21st century.

The report (Education Bureau, Hong Kong 2015) recommends the following key proposals. In the science curriculum, learning and teaching activities are enriched for students to integrate and to apply knowledge and skills in problem solving to create solutions and to make inventions with hands-on and minds-on activities such as project and design-and-make activities. In the Technology and Engineering curriculum, programming, information and communication technology (ICT), material & structure, manufacturing engineering, system and control engineering, and technology & living will be enhanced. Theme-based and design-and-make learning activities are promoted to enhance integration and application of knowledge and skills through project learning among students. In the Mathematics curriculum, data handling and probability content will be strengthened so as to develop students' ability to make informed decision based on calculated risk. The report also recommends various e-resources related to STEM education for effective learning and teaching.

In Hong Kong, number of students taking STEM related disciplines, such as IT and Engineering, at post-secondary level was relatively low which resulted manpower shortage in corresponding industries.

The need for STEM skilled professional is expected to keep increasing. Driven by the government's policy and society needs, focus for future development will be on infrastructure projects and innovation & technology aspects, expected vacancies in related fields are likely to be increased in Hong Kong or even in the Asian region.

Countries like the UK, US and Australia have already kick-started their STEM education promotion. Various efforts have been put to set up STEM Centres to organise various programmes in order to raise the public's interest about the importance of STEM education. Taken an example of the UK, the South West College has established a STEM centre with Multimedia room. The focused activities delivery through the centre support teaching and learning of STEM subjects and design to nurture and to grow innovation and interest in technology. Another example in UK is the STEM Centre of Bournemouth and Poole College, it accommodates a host of renewable technologies including photovoltaic installation, solar heating, heat pumps, water harvesting and wind power which will support sustainability in the region and beyond. Students have the opportunity to study emerging technology fields such as biological sciences with access to cutting edge laboratories. The University of Sydney set up the STEM education centre. It shares a common goal to motivate and engage the next generation of scientists and engineers. It is designed to forge links between high school students, researchers and scientists and will also be accessible to students at other high schools in Sydney's Greater West.

In response to the government policy to promote STEM education and training as well as the market needs, VTC takes proactive role to promote STEM education in VPET. Liu (Liu 2016) proposed a

framework to establish three STEM education centres in VTC to serve a platform for cross-disciplinary development. The IVE Engineering Discipline (Lee 2015) continues to develop international exchange activities with STEM elements to foster talented engineers globally. In June 2016, VTC (IVE engineering discipline newsletter 2016) hosted an international STEM students forum aims to engage youth in STEM studies by inviting STEM students from all over the World to share ideas. Participants included students from Australia, United Kingdom, Singapore and Hong Kong. All students are studying STEM-related subjects ranging from electrical, mechanical and civil engineering; to digital media and medical science. Students presented their joint projects as well as STEM career development in their countries. Similar event with larger scale will be organised by VTC in June 2017.

VTC STEM Education Centre

After considering the local situation and the experience of other countries, 4 strategies are proposed to promote the STEM education effectively.

1. **STEM Student Support:** To strengthen education support to students studying Higher Diploma and Diploma programmes offered by VTC. Since a considerable number of students are came from non-STEM background, their proficiency in fundamental STEM subjects such as Mathematics or Science are needed to be enhanced.
2. **Study Interest in STEM related subjects:** To raise students' interest in STEM subjects and their awareness of STEM related careers, and consequently, increase uptake of STEM subjects at secondary schools and VTC programmes.
3. **STEM Teacher Support:** To enhance professional development of STEM teachers in secondary and vocational education which help to stimulate the teaching and learning quality.
4. **Career Interest in STEM related Industries:** To attract young students to STEM careers which may help to create a stable manpower pool to support the sustainable development of the industries.

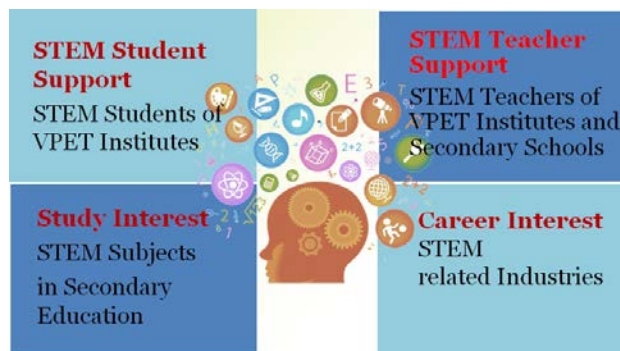


Figure 1 STEM Education Strategies

STEM Education indeed should be delivered at cross-disciplinary level. The establishment of the STEM Education Centre in VTC could pool the resources of the three STEM disciplines from Applied Science (AS), Engineering (ENG) and Information Technology (IT). It serves as a platform for relevant students and staff to deliver curriculum on related trade and cross-disciplinary projects. Moreover, the proposed Centre could help to inspire innovative pedagogy to enhance the learning and teaching experience at post-secondary and secondary level. At publicity angle, the Centre could serve as iconic facility in town to promote STEM education through organizing seminars, workshops and even international events.

For the STEM student support, there are a considerable number of secondary school students from non-STEM background to study VTC programmes, their proficiency in fundamental STEM subjects such as Mathematics or Science are needed to be enhanced. Mathematics and Science Help Desk will be setup to provide them with additional support outside classroom. Teaching staff will be on-duty to provide necessary assistance. Peers influence is always important to young people. To ride on the vehicle of internationalization, Hong Kong students could broaden their horizon and get inspiration on STEM study through exchange with overseas STEM students. Taken the successful MIT summer workshop organized by IVE Engineering Discipline as an example, IVE students were inspired by the MIT students in various areas, such as study method, insight of STEM industries development as well as interests in STEM subjects. STEM exchange activities can be conducted in the Centre locally or through video conferencing at different countries. The use of new technology to enhance learning and teaching of STEM subjects including theory and practical training is essential to youngsters. Taking the AR/VR based learning as example, through 3D simulation, the facility can allow student to expose into a virtual environment such that they can gain a better understanding about the real workplace and, particularly, the possible danger behind.

Support to STEM teachers is equally important. The Centre aims to provide online resources and teacher training. Online resources for teachers of secondary schools on STEM subjects and pedagogical content knowledge, and ultimately enhance the teaching and learning quality. Teachers training programmes will be focused on problem-based learning and project-based learning as a form of continuing professional development. New technology comes and supersedes the old ones. Our society moves with technological advancement everyday. Teachers are also required to connect with latest technology and to understand the trend and move of the industry. Therefore, two approaches are also proposed as support to STEM teachers. The first approach is to encourage VPET teaching staff to conduct Applied Research. The second one is to engage VPET teaching staff with industrial attachment as a form of staff development.

Secondary schools students are the main target for the STEM education promotion. The STEM Education

Centre aims to inspire secondary students by providing venue and support for organizing STEM activities including hands-on workshop and competition to cater for their interests and abilities, and to unleash their potential. To further inspire secondary students, introduction of STEM careers through experiencing in virtual workplace would be more effective. The proposed Centre will equip AR/VR facility to provide students with an interesting touch with the industry. They can also gain a better understanding about the workplaces and the professions. The Centre will also partner with various STEM related industries to organise industry talks and study visits to cutting-edge STEM research and development institutions, such as Hong Kong Science & Technology Park and Cyberport. Moreover, the Centre can help to drive the development of other STEM related programmes for secondary students such as Applied Learning (ApL) programmes and summer camp to help them to explore STEM study at post-secondary level.

The STEM Education Centre is mainly comprised of 4 main zones: Virtual Experience Zone, Mathematics and Science Corner, Engineering and Technology Zone and STEM Activity Workshop. Each zone is embedded with different focus. In virtual experience zone, through virtual reality, the zone can provide students with immersive simulated environment for virtual workplace experience. In Mathematics and Science corner, teaching staff will be on-duty to provide additional support to students, hoping to enhance their proficiency in mathematics and science subjects under a more relaxed setting. In Engineering and Technology Zone, showcase of outstanding STEM projects, such as robotics, solar car, bridge building etc. can be set up to arouse students' interest of STEM education. Finally, the STEM Activity Workshop will equip with hands-on tools and latest equipment such as 3D printers and laser scanner. Interesting STEM related activities will be organized for secondary school students.

In summary, the STEM Education Centre will serve as a cross-disciplinary platform to support relevant students for better study of STEM related programmes, support staff to deliver curriculum on related trade with innovative pedagogy to enhance the learning and teaching experience. It also serves as a focal point of VPET to interface with secondary schools with the aim to help promoting STEM education in Hong Kong and ultimately nurture young STEM skilled professionals for the sustainable development of the Region.



Figure 2 STEM Education Centre

International Exchange Activities

IVE Engineering Discipline (KNCT 2011, Lee 2013, Shirahama & Lee 2013) has started student exchange programmes with NITs from Japan; Ngee Ann Polytechnic and ITE from Singapore; MIT from US and RMIT from Australia etc. since 2009. Both staff members strongly believe that STEM elements are the key successful factor for student exchange programmes. Therefore, the team designed a number of STEM projects in the past eight years. It included control of path tracking mobile robot, design and make of air balloon, control of solar tracking system, and efficiency analysis of a renewable energy system etc. The STEM projects can enhance their hands-on ability to solve daily life problems. On top of STEM project, each exchange programme also included factory visit, cultural exchange and sightseeing activities. The proportion between STEM project and factory visit to sightseeing and cultural activities is around 80% to 20%. This golden rule adopted for many years with good feedback from students, staff members and fund supporters. Throughout these exchange programmes, students can gain more insight of STEM education and career development in different countries.

Project competition is another channel to promote STEM education. Throughout the years, VTC students attended a number of STEM project competitions. For example, VTC students have a long record to participate World Skills Competitions in various trades such as mobile robotics, mechatronics, and software applications etc. The Solar Car and Robocon teams from IVE Engineering Discipline attended the World Solar Challenge in Australia and the Hong Kong Robocon Contest with good achievement. Students are strengthened to solve real life problems with sound engineering principle solution through STEM project competitions. Students also exchange view for code of practice to apply STEM principles to solve real life problems from various countries.



Figure 3 Path Tracking Mobile Robot STEM Project

International STEM Students Seminar/Forum

Apart from the student exchange programmes, international symposium and seminar are also important

event to promote STEM education globally. In 2013, VTC hosted the 3rd International Symposium on Technology for Sustainability (ISTS) and the symposium provides golden opportunity for students to exchange their outstanding STEM projects. It also enhances the understanding the STEM career development in different countries.

In June 2016, VTC organised an International STEM Students Forum in Worlddidac Asia 2016. The theme of the forum is “STEM Students Conversation: What’s Next”. The forum aims to exchange views about STEM students’ learning and teaching experiences and their career development in their countries. There are three sessions of the forum. The first part is outstanding STEM project presentations. Students from RMIT, Australia; the University of the West of England, United Kingdom; Nanyang Polytechnic, Singapore to present joint STEM projects with IVE Engineering Discipline, IVE Information Technology Discipline and Their students respectively. The second part was an invited presentation from the University of the West of England (UWE) to share how UWE engages youth in STEM studies through their signature “Bloodhound” Project. It is a design and make of a supersonic car project. The last part was a student-centre forum. Students from different countries shared their STEM learning experience, career development and views on STEM education and development in their home country. The forum is a successful event with over 300 participants globally.

An International STEM Student Seminar 2017 will be hosted by VTC in June 2017 in Hong Kong. Theme of the seminar is “Voice of Youth: International STEM Students Exchange on Vocational Learning”. The seminar is scheduled for two days and sessions include (i) STEM Students’ forum with Executives, (ii) Invited presentations from STEM teachers/practitioners, (iii) Joint-institute student project presentation, (iv) Student project presentation from different institutions, and (v) Student poster session. Oral presentations and poster session will be reviewed by a technical programme committee. The poster session provides an opportunity for STEM students to present their projects to the Hong Kong and overseas participants in a lively style. Throughout these seminars, it aims to establish an intercultural dialogue among young people from different parts of the world on STEM issues. Also, it can expand the professional networks available to STEM students intending to enter the job market.



Figure 4 International STEM Students Forum 2016

Conclusions

The paper reported various promotion channels of STEM education in vocational and professional education and training (VPET). STEM education centre, international exchange programme, project competition and international student symposium/seminar have been addressed as key elements to promote STEM education.

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