Executive Summary

STEM is an acronym for Science, Technology, Engineering and Education; STEM education refers to the multidisciplinary teaching of these subjects. STEM education emphasises helping students cultivate innovative mindsets, developing interests in these subjects as well as enhancing their creativity, problem-solving skills, logical thinking and capability to engage in collaboration.

Believing that STEM education can help nurture talent and maintain national competitiveness, many countries have stressed the importance of STEM education in recent years. The 2015 Trends in International Mathematics and Science Study (TIMSS) reports that the grade four and grade eight students of more than seventy-five per cent of countries showed improvement in performance in Science and Mathematics, as they got higher scores in their assessments. According to research done by the Programme for International Student Assessment (PISA) in 2015, students in countries that actively implement STEM education showed better performance in collaborative problem-solving assessment than those from other countries.

For three consecutive years, since 2015, the Hong Kong government has stressed the importance of promoting STEM education, promising to take a series of measures to support schools implementing policies for STEM education. An example of such measures is the one-off grant to government schools, aided schools, Direct Subsidy Scheme (DSS) schools and primary schools. Last year, each local secondary school was given an additional one-off subsidy amounting to $200,000.

Apart from the government, all higher education institutions and many enterprises and non-governmental organisations have recently been actively offering different kinds of resources to promote the development of STEM education. However, when examining the recent development of STEM education among secondary schools, it is not difficult to discover that quite a number of schools lack defined goals and plans for the development of STEM education. Moreover, they are

unable to fully utilise their resources to effectively develop STEM education.

This research aims to examine the usage of STEM education resources by local secondary schools. Particular attention is given to the government's one-off grant, amounting to $200,000 per school. In addition, in order to encourage education workers to better utilise resources for sustainable, long-term development of STEM education, this research attempts to share successful experiences through case studies.

From November to December 2017, questionnaires were distributed to teachers responsible for the coordination of STEM education. 105 completed questionnaires were collected. At the same time, nine discussions groups as well as interviews with five experts or academics were also conducted.

Main Discussion

1. **Making good use of resources is the key to the development of STEM education in secondary schools. Effective resource allocation could help the promotion of STEM education among schools and support their implementation of STEM education programmes. Also, it could encourage social organisations to take part in STEM education. Prudent resource utilisation could contribute to effectiveness in promoting STEM education.**

   According to the survey results, nearly eighty per cent (78.8%) of the teachers agreed that their schools started implementing STEM education after the government had disbursed a one-off grant, which amounted to $200,000 per school, for STEM education. More than eighty per cent (83.6%) of the teachers affirmed the usefulness of the one-off grant for helping schools develop STEM education.

   After the government disbursed the one-off grant for STEM education, the number of educational institutions and social organisations

promoting STEM education has increased rapidly. This has been followed by a huge rise in the number of STEM-related competitions, exhibitions, courses and activities.

Good resource allocation is crucial to the promotion of STEM education among secondary schools. Firstly, with resources allocated to it, schools put greater emphasis on STEM education and include it in school development projects. Secondly, financial assistance enables schools to carry out their STEM education plans based on their own needs. With such monetary support, schools can purchase equipment and services and organise activities. Thirdly, resource allocation can provide incentives to social organisations to get involved in the development of STEM education. This in turns gives rise to different kinds of STEM education projects and increases the diversity of STEM educational resources. Schools are thus open to more directions and methods of STEM education development. Fourthly, resource allocation can facilitate society's popularisation, and thus the universality, of STEM education.

2. **There is a lack of guidelines and examples regarding STEM education for schools' reference. Schools' understanding of and planned directions for STEM education are the prerequisites of effective resource utilisation. The government should provide schools with sufficient guidelines and examples for schools' reference in order to help schools work on their directions and strategies for developing STEM education.**

   The survey results reveal that almost half (48.5%) of the teachers believed that the guidelines on STEM education offered by the Education Bureau lacked clarity. About sixty per cent (57.3%) of the teachers agreed that the examples of STEM education development for schools' reference were not enough.

   Nowadays, the Education Bureau only offers Mathematics and Sciences curriculum guides; a clear and complete curriculum guide for STEM education is absent. Also, examples of STEM education development for schools' reference are insufficient. It is understandable that some schools are unsuccessful in developing STEM education programmes despite the

best intentions. Since most schools have never developed STEM education, some schools might find difficulties starting up the development of STEM education. Therefore, in order to help schools develop their plans regarding STEM education, the government should provide sufficient guidelines and examples for school reference.

3. **Most of the schools have not fully utilised their resources to implement STEM education. Currently, many schools are carrying out different kinds of STEM education projects, but since resources are not fully utilised, the development of STEM education is slow and lacks focus.**

The survey results show that almost twenty per cent (19.0%) of the schools did not cooperate with the government and other parties to organise STEM-related activities. Only about ten per cent (9.5%) were involved in cross-district cooperation with other schools. Nearly ten per cent (8.6%) of the schools cooperated with other schools with the same sponsoring body. Less than six per cent (5.7%) cooperated with other schools located in the same district. Furthermore, the school participation rate in STEM education programmes was quite low. This reflects the fact that resources for STEM education have not been fully utilised by the schools.

Some schools were too reliant on government subsidies. They were not active in searching for additional resources to implement STEM education. This results in slow progress in the development of STEM education. Even though enterprises possess enormous resources that could be used for developing STEM education, these schools were not active in seeking opportunities for cooperation with such enterprises and make good use of their resources.

Due to the limited resources and facilities of each school, schools could only focus on the development of one academic discipline of STEM. STEM education could be implemented more effectively if there were cooperation among schools. With each school is responsible for a specific discipline of STEM education, schools could provide training to teachers, who would acquire knowledge and learn teaching methods for their

respective disciplines. They could also purchase equipment based on specific needs to develop their respective disciplines and could share resources with partner schools.

4. **The prevailing method of implementing STEM education in secondary schools lacks sustainability and universality. Although schools and other stakeholders are involved in the promotion of STEM education, their plans are not prepared with long-term development in mind. This makes STEM education difficult to implement in a sustainable way.**

   As educators, teachers are responsible for STEM education. An abundance of professional development training programmes for teachers is the key to sustainable implementation of STEM education. According to the survey results, almost half (48.6%) of teachers think that STEM-related professional development training opportunities are inadequate. However, only about twelve per cent (11.4%) of teachers spent some of the one-off grant on professional development training. Among this group, nearly ninety-two per cent (91.7%) spent less than one-tenth of the grant on training. If STEM education is to be implemented in the long run, the problem of deficient professional development training programmes must be tackled.

   Cultivating students' interest in STEM helps with the long-term development of STEM education. If STEM education is implemented in junior secondary schools, more students are exposed to STEM and might develop interest in it. It also serves to help students lay the foundation for future development of STEM in senior secondary schools. Besides, universities' minimum entrance requirements for the four core subjects – Level 3 in Chinese Language and English Language and Level 2 in Mathematics and Liberal Studies – leads to students focusing on the preparation for examinations in these subjects. This lowers students' interests in choosing STEM-related elective subjects; it is unfavourable for students choosing to study STEM-related subjects at undergraduate level and developing a career in the field of STEM.

   To achieve long-term, sustainable implementation of STEM education, STEM education projects must be carried out regularly and successively. Furthermore, every student should be offered the opportunity to partake

in these projects. However, most of the resources, activities and projects currently offered are either one-offs or short-term events; the coverage is not extensive enough to allow all students to benefit.

5. **The way the government allocates resources is ineffective in developing STEM education. Since not all the schools can benefit from these policies, these resources are wasted to a degree.**

The survey results reveal that about seventy-five per cent (75.7%) of the respondents believed that lesson time allocated to STEM education is insufficient. Almost forty per cent (37.9%) felt that the resources allocated to STEM education are inadequate. Among all the governmental projects and resources for developing STEM education, one-off grants and the sharing of good practices were the most popular options in terms of usage rate and recognition. The usage rates of other governmental projects were low. This demonstrates that the government has not used its resources effectively.

The scale of activities offered by the government is either too large for constructive participation or too small for universal participation. Furthermore, the government disbursed the one-off grant to every single school, meaning that schools obtained limited capital for developing STEM education, which could not be used effectively.

The government is the policy-maker and the most influential resource provider, so its form of resource allocation and the amount of resources offered are the determinants of utility maximisation. If the government fails to use resources in an effective way, not only will schools not be benefited, but resources will be wasted. Such ineffective use, and thus waste, of resources reduces the universality and effective implementation of STEM education.

Recommendations

This study makes the following recommendations based on three

principles, including the improvement of the usage of resources, enhancement of both the level of sustainability and the universality of STEM education projects and a change in the mode of government resource allocation for better resource utilisation:

1. **Establish a STEM education fund of one billion dollars.**

   STEM education is extremely important for improving Hong Kong's competitiveness. With reference to overseas cases, this research suggests that, since Hong Kong's financial position is robust, the government could offer more resources for STEM education development in the new financial year. The government could propose the establishment of a STEM education fund of one billion dollars in the fiscal budget. The STEM education fund would offer financial assistance and resources for the comprehensive development of STEM education. It could support academic staff and technicians as well as pay for professional teacher training, course materials, equipment and activities. This in turn would enable the long-term, sustainable implementation of STEM education.

   To maximise the gains of resource utilisation, this study also suggests the establishment of thematic networks under the STEM education fund. A school that is financially supported by the STEM education fund will be requested to be a coordinator after their STEM education project has been completed. The school will then be responsible for establishing a network of schools sharing the intention of developing a specific area of STEM education. The coordinating school would cooperate with other schools in the same network to design school-based STEM learning modules and determine the future direction of schools.

2. **Provide guidelines and examples for schools' reference.**

   This research reveals that schools need clear concepts and directions regarding STEM education for there to be effective and focused development of school-based STEM education. Such concepts and directions originate from the guidelines and examples provided for schools' reference by the government. Since STEM is not a single subject, it is difficult to allocate lesson time for the implementation of STEM

education. Also, it is hard to formulate curriculum guides. The STEM-related curriculum guides currently offered are limited to Mathematics and Science. These curriculum guides are not multidisciplinary in nature and do not make reference to the cultivation of innovative mindsets.

It is recommended that the government should provide guidelines and examples for schools' reference in the field of STEM education. The guidelines should list for secondary schools orientations, strategies, learning goals, learning scopes, key learning areas, teaching and learning material, etc. These would help schools have a clearer concept of STEM education development.

With reference to overseas experiences, this research also recommends the government set up an interdepartmental coordinating committee responsible for developing STEM education. The committee could systematically plan and evaluate strategies and resource allocation for STEM education development. This would enable STEM education policy to be more comprehensive and focused.

3. **Set up STEM resource sharing centres in the five constituencies of Hong Kong.**

Implementation of STEM education involves the use of different kinds of facilities. Most of these facilities are expensive and change rapidly over time. Therefore, schools could only purchase one-of-a-kind facilities; they could not carry out diverse educational activities. At the same time, when schools buy and use facilities for their own use, the usage rates of these facilities are not high. This in turn hinders resource utilisation. In 2017, the government established the STEM education Centre in Lok Fu, located in Kowloon East. The Centre provides schools with facilities, professional development training programmes for teachers and student learning activities. The Centre serves to centralise resources, which can be shared among schools. It can offer effective support services to schools.

This research suggests an expansion of the STEM Education Centre. Expansion of the STEM Education Centre can be set up in vacant school

premises and community centres in the five constituencies of Hong Kong. Apart from Kowloon East, additional STEM Education Centre locations could be established in Kowloon West, New Territories East, New Territories West and Hong Kong Island. With facilities shared among schools, schools in every constituency would have access to STEM facilities and support services.

4. Enhance software and facilities in the Hong Kong Science Museum

In recent times, the items on display in the permanent exhibition of the Hong Kong Science Museum are for primary school level. They have been unable to catch up with scientific development. The Daily Science Demonstration is quite simple and cannot help secondary school students acquire scientific knowledge after class.

With reference to overseas experiences, this research offers several suggestions for the better utilisation of the facilities in the Hong Kong Science Museum and strengthening the bond between the Museum and secondary schools. The government could enhance and renew the software and facilities in the Hong Kong Science Museum. The content and demonstrations could also be updated regularly. In addition, laboratories and a Science Room specifically for cooperation with schools in Hong Kong could be set up. They could organise STEM education activities that cannot be carried out by schools due to the constraints of their facilities and other environmental factors.