

Promotion of STEM Education

Unleashing Potential in Innovation

Overview



Curriculum Development Council
November 2015

Preamble

Promotion of STEM Education

This document entitled *Promotion of STEM Education – Unleashing Potential in Innovation* is issued to solicit views and comments from various stakeholders in the education and other sectors of the community on the recommendations and proposed strategies for the promotion of STEM education among schools in Hong Kong. It should be read in conjunction with the separate *Briefs for Updating the Science, Technology and Mathematics Education Key Learning Area (KLA) Curricula*.

The recommendations and strategies proposed in this document on promoting STEM education have a direct bearing on school-based curriculum development over the next decade, and chart the way forward for sustaining the ongoing renewal of the school curriculum. Comments and suggestions on this document are welcome and should be sent to the following by 4 January 2016:

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Promotion of STEM Education - Unleashing Potential in Innovation

Introduction

1. STEM is an acronym that refers to the academic disciplines of Science, Technology, Engineering and Mathematics collectively. The promotion of STEM education aligns with the worldwide education trend of equipping students to meet the changes and challenges in our society and around the world with rapid economic, scientific and technological developments.
2. In the curriculum context of Hong Kong, STEM education is promoted through Science, Technology and Mathematics Education. As stated in the 2015 Policy Address, EDB will renew and enrich the curricula and learning activities of Science, Technology and Mathematics, and enhance the training of teachers, thereby allowing primary and secondary students to fully unleash their potential in innovation.

Why is it Necessary to Promote STEM Education?

3. To maintain the international competitiveness of Hong Kong, a range of talents with different capabilities and at different levels are required to fulfill the needs of economic, scientific and technological developments in the contemporary world, especially when opportunities arise for Hong Kong to contribute to major initiatives for national developments, e.g. the “Belt and Road” initiative. Along this line, the Government is actively promoting Innovation and Technology, and the public awareness of the importance of innovation in STEM-related fields is increasing. These macro changing contexts call for the promotion of STEM education in schools.
4. Promotion of STEM education is introduced as a key emphasis under the ongoing renewal of the school curriculum (also known as Learning to Learn 2.0), to nurture students to become effective lifelong learners equipped with appropriate knowledge, generic skills as well as values and attitudes necessary for facing challenges in the 21st century.
5. Hong Kong students have generally performed well in science, technology and mathematics over the years as revealed from international studies (e.g. PISA, TIMSS) and competitions (e.g. International Junior Science Olympiad, Intel International Science and Engineering Fair). On the whole, they actively participate in a wide range of learning activities related to STEM disciplines inside and outside schools.
6. While Hong Kong students perform well in science, technology and mathematics, they may focus on disciplinary studies and may not evenly participate in hands-on activities in schools. Therefore, it is necessary to strengthen the ability of students to **integrate and apply** their knowledge and skills across different subject disciplines through solving daily life problems with practical solutions and innovative designs. Besides, although the elements of STEM education are embedded in individual KLAs of Science, Technology and Mathematics Education of the local school curriculum, the coherence and collaboration among teachers of the three KLAs in planning and organising STEM related learning activities need to be strengthened. The promotion of STEM education provides an opportunity for teachers of these KLAs to collaborate and further enhance the effectiveness of learning and teaching.

What is the Direction for Promoting STEM Education?

Guiding Principles for Promoting STEM Education

7. When promoting STEM education, reference has been made to the local, the Mainland and international experiences, the educational trends of equipping students with appropriate knowledge and skills to meet the changes and challenges in society and around the world, as well as the ongoing renewal of the school curriculum for whole-person development and lifelong learning. The guiding principles for promoting STEM education are:
 - i. *Learner-centred approaches*
To facilitate students to learn how to learn through STEM-related learning activities, diversified learning, teaching and assessment strategies should be used to suit the needs and interests of students.
 - ii. *Essential learning experiences*
All students have the ability to learn, and they should be provided with STEM-related learning opportunities which form part of the essential learning experiences, that include learning opportunities beyond classroom.
 - iii. *Balance among different purposes, views and interests*
In promoting STEM education, a balance has to be struck with considerations of students' interests and needs, teachers' views and partnerships with community key stakeholders.
 - iv. *Building on strengths*
The promotion of STEM education in Hong Kong is building on school experiences and other conducive factors, such as the flexible use of learning time and life-wide learning experiences.
 - v. *Continuous development process*
Promoting STEM education at school level is a continuous and dynamic improvement process. This could start with small scale curriculum development projects which allow tolerance of ambiguity and room for further advancement.

Aim and Objectives of Promoting STEM Education

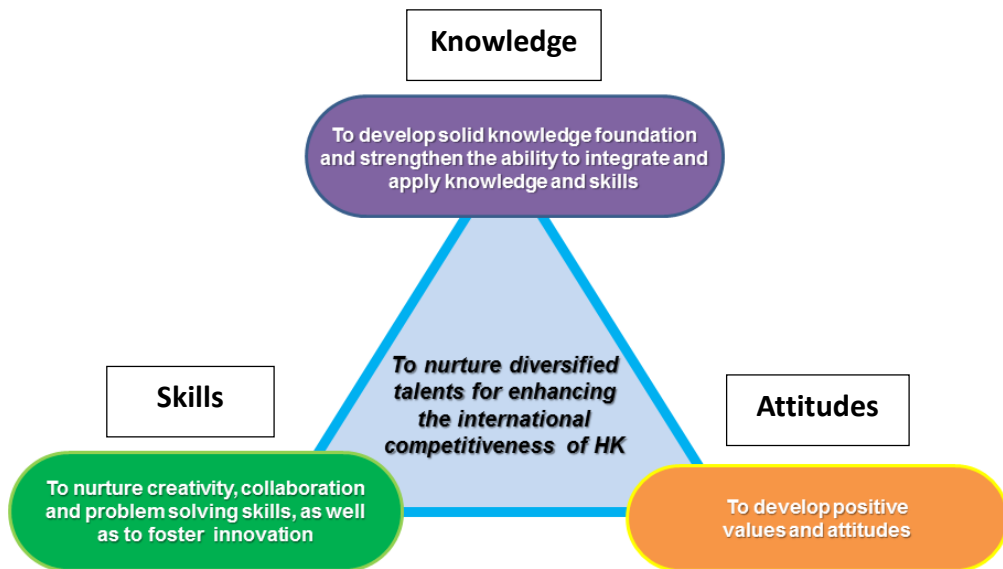
8. When formulating the aim and objectives of promoting STEM education in Hong Kong, considerations have been made on the guiding principles for the ongoing renewal of the school curriculum (also known as Learning to Learn 2.0) as recommended by the Curriculum Development Council (CDC). Reference can be made to the *Overview for Ongoing Renewal of the School Curriculum – Focusing, Deepening and Sustaining*. In gist, the promotion of STEM education in schools of Hong Kong aims to strengthen the Science, Technology and Mathematics Education to nurture diversified talents in the science and technology fields for enhancing the international competitiveness of Hong Kong. The specific objectives include:

- To develop among students a solid knowledge base and to enhance their interests in Science, Technology and Mathematics for further studies and careers in meeting the changes and challenges in the contemporary world
- To strengthen students' ability to integrate and apply knowledge and skills, and to nurture students' creativity, collaboration and problem solving skills, as well as to foster their innovation and entrepreneurial spirit as required in the 21st century
- To strengthen the professional capacity of and collaboration among teachers in schools and the partnerships with community stakeholders
- To nurture talents and develop experts in STEM areas so as to contribute to the development of Hong Kong and its strategic position in national developments, e.g. the "Belt and Road" initiative

What are the Recommendations for STEM Education in Hong Kong?

Strengthening the Ability to Integrate and Apply

9. Through integration and application of knowledge and skills of the KLAs of Science, Technology and Mathematics Education, students would realise that the development of science, technology and mathematics is closely related to the societal environment and that the advancement in science and technology could help improve the quality of life in the contemporary world.
10. The experiences of integrating and applying knowledge and skills to solve authentic problems and make inventions would help the development of positive values and attitudes among students as part of whole-person development. These learning opportunities can facilitate their career explorations in STEM fields and the nurturing of entrepreneurial spirit. This would not only enhance students' interest in STEM areas, but also enable them to prepare for their future studies and careers in the areas and other fields requiring relevant knowledge, skills and attitudes.

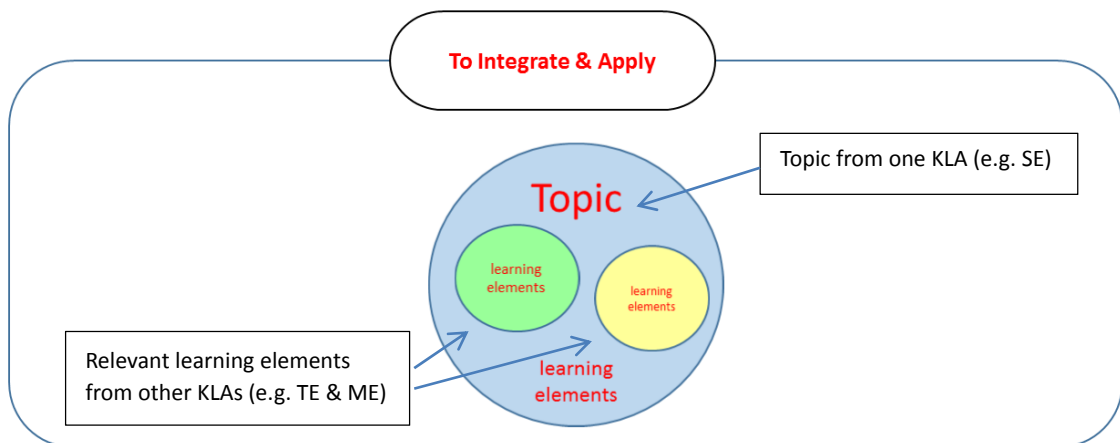


Approaches for Organising Learning Activities on STEM Education

11. With the focus on strengthening students' ability to **integrate and apply knowledge and skills** within and across the KLAs of Science, Technology and Mathematics Education, the following two approaches for organising learning activities on STEM education are recommended:

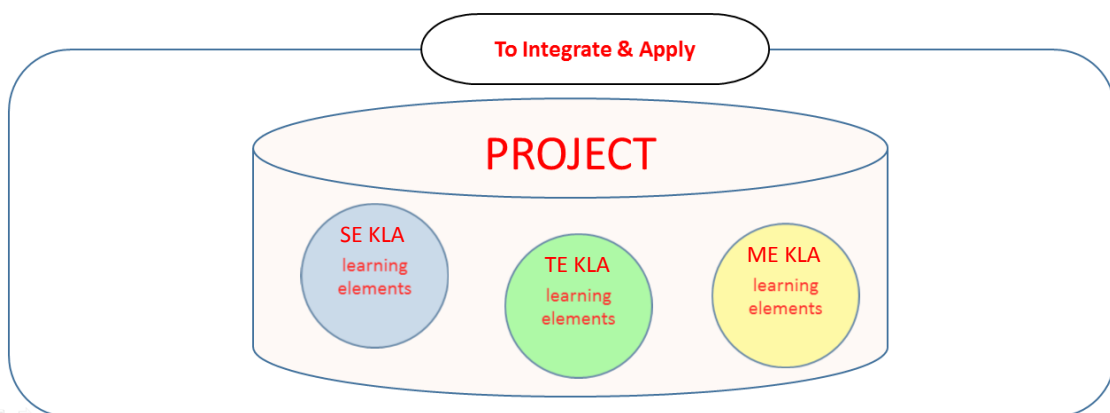
Approach One

Learning activities based on topics of a KLA for students to integrate relevant learning elements from other KLAs



Approach Two

Projects for students to integrate relevant learning elements from different KLAs



Teacher Collaboration and Community Partnership

12. As the KLAs of Science, Technology and Mathematics Education are closely connected in the promotion of STEM education, teachers concerned are encouraged to strengthen the cross-disciplinary collaboration at school level in planning and organising KLA-based and cross-KLA learning activities for students.
13. To facilitate the promotion of STEM education among schools, community partnerships with academics and practitioners specialising in various fields of science, technology, engineering and mathematics, as well as professional bodies and other relevant organisations, have to be fostered for the benefit of student learning.

What are the Strategies for Promoting STEM Education?

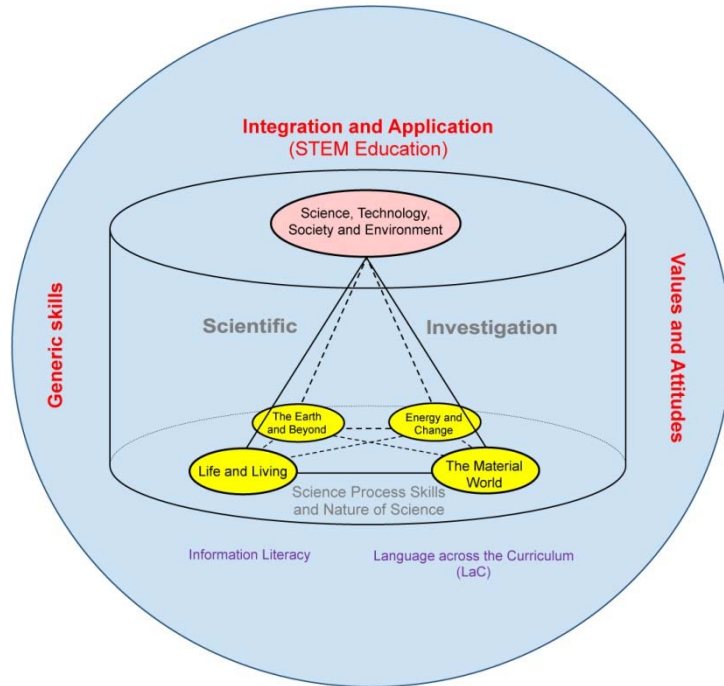
14. In promoting STEM education, we have adopted a holistic approach through different strategies focusing on strengthening students' ability to integrate and apply knowledge and skills of different disciplines in school education so as to unleash their potential in innovation.
15. The following six strategies are proposed:
 - (1) Renew the curricula of Science, Technology and Mathematics Education KLAs;
 - (2) Enrich learning activities for students;
 - (3) Provide learning and teaching resources;
 - (4) Enhance professional development of schools and teachers;
 - (5) Strengthen partnerships with community key stakeholders; and
 - (6) Conduct review and disseminate good practices.

Strategy 1 Renew the Curricula of Science, Technology and Mathematics Education KLAs

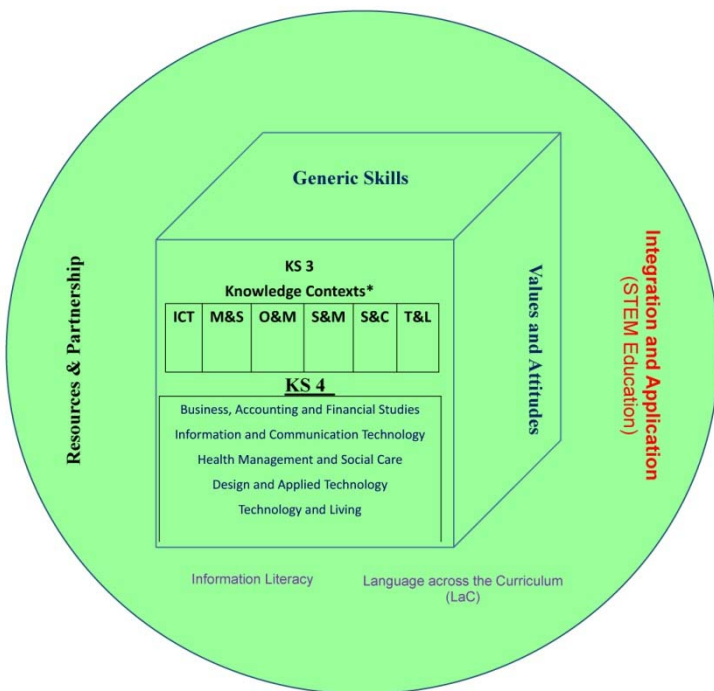
We are renewing the curricula of the Science, Technology and Mathematics Education KLAs and the primary General Studies curriculum in accordance with a set of guiding principles set out by the CDC in October 2015 and considerations specific to promoting STEM education given in para. 7. Reference can also be made to the separate *Briefs for Updating the Science, Technology and Mathematics Education KLA Curricula*.

- 1.1 To update the curriculum frameworks of Science, Technology and Mathematics Education KLAs highlighting the importance of strengthening students' integration and application of knowledge and skills across disciplines.

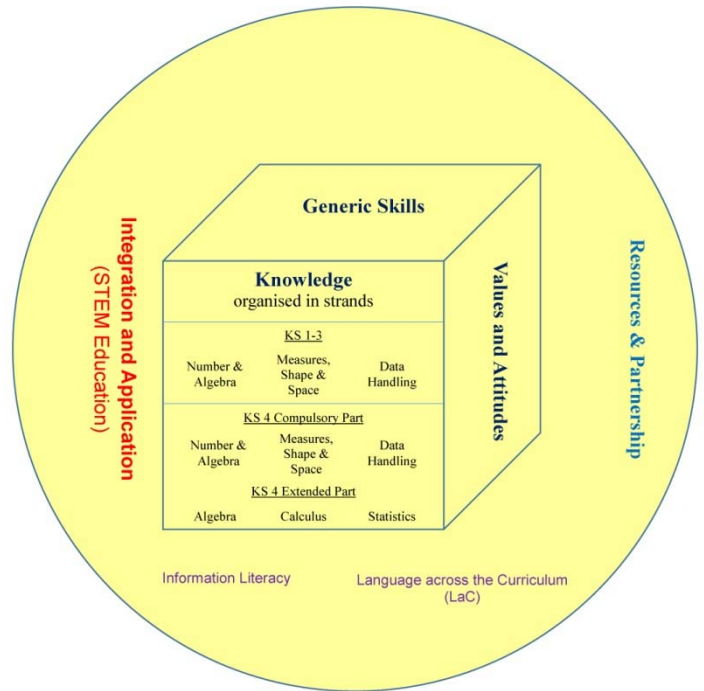
Curriculum Frameworks of Science, Technology and Mathematics Education KLAs



Science Education KLA



Technology Education KLA



Mathematics Education KLA

- 1.2 To update the curriculum contents to keep students abreast of the latest developments in various fields of science and technology, and to suggest learning and teaching activities for teachers' reference.

Major updates of Science (Secondary 1-3) curriculum

- The contents are updated to keep abreast of the rapid development in science and technology, especially in the field of life sciences (e.g. DNA as the book of life, Biotechnology and health).
- Some contents are fine-tuned to strengthen the bridging between junior and senior secondary science curricula (e.g. Elements and atoms, Periodic table).
- Unifying concepts are introduced to enhance students' understanding of the connections and overarching coherence across different science disciplines.
- Science process skills are strengthened, in particular about the basic quantitative treatment in scientific investigations, including interpretation of data and graphs, and use of symbols, equations and graphs for representation and communication of ideas.
- Learning and teaching activities are enriched for students to integrate and apply knowledge and skills in problem solving to create solutions and make inventions with hands-on and minds-on activities (e.g. projects and design-and-make activities).

Major updates of Technology Education KLA (Secondary 1-3) curriculum

- At least 30% of curriculum time under Information & Communication Technology (ICT) is allocated to learning and teaching of programming concepts (including coding).
- The six knowledge contexts under the TEKLA curriculum, namely ICT, Materials & Structures, Operations & Manufacturing, Strategies & Management, Systems & Control, and Technology &

Living are grouped into 16 core and 10 extension modules to ensure students to acquire common and concrete knowledge base.

- All schools are recommended to offer the core modules with 8% of the curriculum time. Some schools may offer extension modules to meet different needs of their students (up to 15% of the curriculum time).
- Theme-based and design-and-make learning activities are promoted to enhance integration and application of knowledge and skills through project learning among students.
- Students' interests and curiosity are cultivated through hands-on and minds-on STEM related activities, which allow them to solve problems and create solutions for the well-being of humankind.

Major updates of Mathematics curriculum

- Holistic and multi-stage review of Mathematics curriculum (P1-S6) is planned to carry out to address the issues like enhancing vertical continuity/progression in Mathematics and lateral alignment with other KLAs, STEM education, and incorporation of other elements for ongoing curriculum renewal.
- The newly suggested learning and teaching sequence and the curriculum framework is intended to
 - (i) enhance the effectiveness of learning and teaching;
 - (ii) enhance the support of Mathematics in STEM education; and
 - (iii) strengthen the learning and teaching of Data Handling and Probability so as to develop students' ability to make informed decision based on calculated risk.
- Learning and teaching activities for students to integrate and apply knowledge and skills, as well as to work out creative solutions, new ideas or calculated

judgment will be strengthened (e.g. project learning, mathematical modeling, problem-based learning).

Major updates of primary General Studies (GS) curriculum

- The contents are updated to put more emphasis on the relevance of science and technology to daily life (e.g. low carbon living, global warming).
 - Basic science process skills, including observing, measuring, classifying and communicating, are enhanced in science investigation (e.g. fair test) to strengthen the interface between primary and junior secondary levels.
 - Learning and teaching activities related to the application of science and technology in solving everyday life problems are enriched (e.g. energy use in daily life, the use of simple machines)
- 1.3 To promote pedagogies that could facilitate students to integrate and apply knowledge and skills (e.g. with the use of scientific investigation, project learning, problem-based learning, design-and-make activities).

Strategy 2 Enrich Learning Activities for Students

EDB is taking actions to enrich learning activities for students to promote the culture of cross-disciplinary learning of Science, Technology and Mathematics.

- 2.1 To organise an education fair for students to showcase and celebrate a wide range of student achievements on STEM-related areas on a regular basis. This signature event will also provide quality learning experiences for students to enhance their interests, creativity and innovation and to strengthen their ability in integrating and applying both knowledge and skills in solving authentic problems.
- 2.2 To advise schools to effectively use school-based flexible time of central time allocation and outside

classroom learning for engaging students in worthwhile learning experiences (e.g. cross-curricular and cross-KLA project learning or competitions).

- 2.3 To broaden students' learning by providing opportunities for them to participate in local, national, and/or international competitions related to STEM to cater for their interests and abilities and to unleash their potential in STEM areas.
- 2.4 To nominate students with special talent in STEM areas to apply for local and overseas scholarships so as to widen their horizons for facilitating their specialisation in future studies on STEM related disciplines.

Strategy 3 Provide Learning and Teaching Resources

Schools are recommended to make good use of existing resources for supporting the implementation of the curricula of the Science, Technology and Mathematics Education KLAs, such as equipment in the special rooms, IT facilities, audio-visual aids, library books, learning and teaching resources packages, to promote STEM education. The resources provision to schools will be enhanced to further support schools to plan and organise STEM related activities for students.

- 3.1 To provide further resource materials for teachers' reference, including annotated school cases, cross-disciplinary activities, project learning, life-wide learning activities, and information on STEM-related competitions. These resources serve to provide insights and tips to schools for organising relevant learning activities within and outside the classroom.
- 3.2 To suggest various e-resources related to STEM disciplines, e.g. e-library, online courses, e-textbooks, and other resources related to STEM education accessed from the Internet, for effective learning and teaching.
- 3.3 To promote the use of learning and teaching resources related to STEM education on the "EDB One-stop

Portal for Learning and Teaching Resources” (OSP) hosted at the Hong Kong Education City Limited (HKECL), and to enrich the resources.

- 3.4 To strengthen the connection between EDB and various organisations, such as Hong Kong Science Park and Hong Kong Science Museum, for effective dissemination of learning and teaching resources and life-wide learning activities.

Strategy 4 Enhance Professional Development of Schools and Teachers

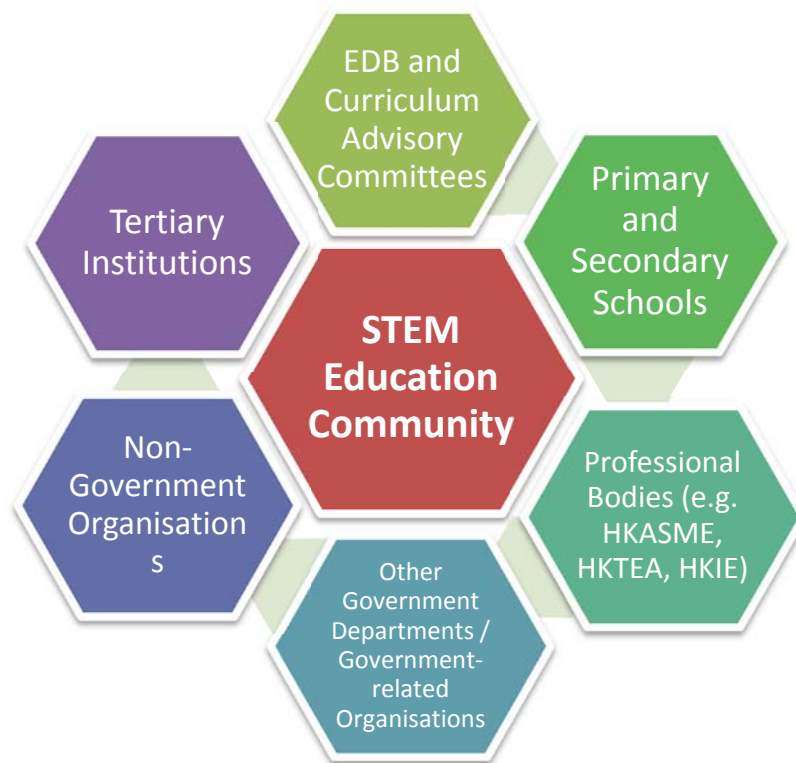
To enhance the professional capacity of school heads, curriculum leaders and teachers in implementing STEM education holistically and effectively at school level, EDB is taking steps in strengthening the relevant professional development programmes (PDPs).

- 4.1 To organise symposia for curriculum leaders on a regular basis. Such signature events aim to serve as a hub for the promotion of STEM education among local schools.
- 4.2 To continue to organise PDPs for middle managers and teachers in the coming three school years to introduce the appropriate strategies for enhancing students’ ability of cross-disciplinary integration and application of knowledge and skills. Seminars and workshops on enriching teachers with the most up-to-date knowledge on STEM-related fields will continue to be organised.
- 4.3 To build communities of practice to enhance knowledge exchange within and across schools through different platforms (e.g. Professional Development Schools Scheme (PDS) of Education Development Fund (EDF) and Quality Education Fund (QEF) Thematic Network).
- 4.4 To enhance teachers’ exposure to cutting edge development in science and technology fields through exchange with academics/partners in the territory and from the Mainland and overseas.

Strategy 5 Strengthen Partnerships with Community Key Players

All along, EDB has been engaging different stakeholders in the promotion of student learning in STEM areas. There is also a need to further strengthen the partnerships with them and maintain professional communities.

- 5.1 To further enhance the communication with local curriculum advisory committees, as well as the school sector, for enhancing student learning in the KLAs of Science, Technology and Mathematics Education.
- 5.2 To strengthen the liaison with academics and practitioners who specialise in various science, technology, engineering and mathematics fields, and to explore the feasibility of collaborating with tertiary institutions and specialists in organising teacher training programmes and student learning activities.
- 5.3 To continue to strengthen the partnerships with professional bodies, and other government and non-government organisations (e.g. Hong Kong Science Park, British Council, Hong Kong Federation of Youth Groups, Hong Kong Association for Science and Mathematics Education) in fostering synergy within the community for the promotion of STEM education among schools.



Partners in the STEM Community

Strategy 6 Conduct Review and Disseminate Good Practices

Good practices from schools in organising learning activities to strengthen students’ ability to integrate and apply knowledge and skills will be consolidated for dissemination to facilitate the promotion of STEM education among schools.

- 6.1 To conduct research and evaluation studies on the implementation of STEM education at school level, and to review the curricula as appropriate.
- 6.2 To continue to identify good school-based practices of implementing STEM education and consolidate experiences from schools on organising cross-disciplinary learning and teaching activities.
- 6.3 To disseminate evidence-based practices through PDPs and Centre of Excellence (CoE), e.g. Professional Development Schools Scheme (PDS) of Education Development Fund (EDF).

Epilogue: *Progressive Approach with Concerted Efforts*

16. The emphasis of promoting STEM education among schools in Hong Kong is to unleash students' potential in innovation and equip them to face the challenges in the contemporary world. It should be noted that the promotion of STEM education in schools involves progressive development in the Science, Technology and Mathematics Education KLAs, and that forms part of the ongoing renewal of the school curriculum. Regarding the promotion of STEM education at the school level, schools could take necessary measures through holistic planning according to their school context to suit the needs and interests of their students. It is hoped that through appropriate strategies and concerted efforts among panels, schools and community stakeholders, the aim and objectives of promoting STEM education could be effectively achieved with enhancement of students' essential skills and qualities for the 21st century.

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