Ongoing Renewal of the
School Curriculum –
Focusing, Deepening and Sustaining

Updating the Science Education
Key Learning Area Curriculum
(Primary 1 to Secondary 6)

Consultation Brief

Curriculum Development Council
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Preamble

On-going Renewal of the School Curriculum – Focusing, Deepening and Sustaining

The Learning to Learn curriculum reform that started in 2001 has been promoting curriculum and pedagogical change that fosters learners' whole-person development and learning to learn capabilities to achieve lifelong learning. Over the past decade or so, much has been achieved in schools through the implementation of the reform. To mention a few of the achievements, the curriculum reform has brought about a new breed of students who are more proactive and in possession of greater learning agility and stronger transferable skills; the strength of our students' performance in mathematics, science and reading in Chinese is internationally recognised; teachers have achieved a paradigm shift from teacher-centred classroom practices to learner-centred learning; the assessment culture in schools has changed with greater emphasis placed on assessment for/as learning; and there is increasing collaboration among teachers within and across schools.

Alongside the implementation of the Learning to Learn curriculum reform, there have been a lot of changes and challenges in our society and around the world, such as those observed in economic, scientific, technological and social developments. To maintain Hong Kong's competitive edge and to prepare our students well for the local and global changes taking place in various fields, it is necessary to enhance the Learning to Learn curriculum reform, to sustain and deepen the accomplishments achieved and to identify new focuses in the curriculum as we move to a new phase of curriculum renewal and updating.

Capitalising on the positive impacts and experience gained, the curriculum renewal (also known as "Learning to Learn 2.0") being introduced is an enhanced version of the Learning to Learn curriculum reform that started in 2001. It is not an "add-on" but a continual journey to work smarter and in a more focused manner in promoting Learning to Learn for the next five to ten years. In this new phase of curriculum renewal, the curriculum will remain learner-centred and continue to focus on learning, particularly the improvement of its quality and effectiveness. However, to closely respond to various contextual changes locally and globally, more attention will be given to the development of personal attributes expected of our students across KLAs in the coming decades, and focuses such as Reading across the Curriculum, Information Literacy, as

well as Science, Technology, Engineering and Mathematics (STEM) Education will be given stronger emphasis with renewed understanding of learning goals, generic skills and values and attitudes.

In response to the new phase of ongoing curriculum renewal, the *Basic Education Curriculum Guide (Primary 1-6)* was updated in mid-2014. The corresponding *Secondary Education Curriculum Guide* and the curriculum guides for the various KLAs are also being updated and will be available for schools' reference in 2016 upon the completion of consultation. Schools are encouraged to sustain, deepen and focus on areas deemed essential for further improving students' independent learning capabilities.

This consultation brief presents the major updates related to the Science Education Key Learning Area (KLA) and the key emphases for the ongoing curriculum renewal proposed for schools' adoption. Examples are also provided to illustrate how these considerations are achieved through this KLA, particularly in the aspects of learning aims/targets/objectives, curriculum planning as well as learning, teaching and assessment. Schools may formulate plans to incorporate these recommended updates and key emphases for the ongoing curriculum renewal from the 2016/17 school year, taking into consideration the school context, teachers' readiness and students' needs. As the recommendations proposed in this consultation brief have a direct bearing on school-based curriculum development over the next decade and will set new directions for future curriculum updating and renewal and chart the way forward for sustaining the existing curriculum reform, we would like to solicit views and feedback from stakeholders, in particular the school sector. Comments and suggestions on this consultation brief are welcome and should be sent by 4 January 2016 to:

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1. Why and how is the science curriculum updated?

The *Science Education Key Learning Area Curriculum Guide (Primary 1 - Secondary 6)* (2016) is prepared by the Curriculum Development Council (CDC) Committee on Science Education. It is an updated version of the *Science Education Key Learning Area Curriculum Guide (Primary 1 - Secondary 3)* (2002) and has been extended to include the three-year senior secondary science education. The curriculum framework of the Science Education KLA comprises six strands, namely **Scientific Investigation**, **Life and Living**, **The Material World**, **Energy and Change**, **The Earth and Beyond**, and **Science, Technology, Society and Environment (STSE)** with **STEM[1] education** and other key emphases of the ongoing curriculum renewal. STEM education is highlighted as the focus of development of the ongoing renewal of the school science curriculum. Subjects of the Science Education KLA include the primary General Studies which consists of science learning elements, Science (Secondary 1-3) and Biology, Chemistry, Physics and Science (Mode I: Integrated Science; Mode II: Combined Science) for Secondary 4 to 6.

In response to the changing needs of the society, the rapid development of science, technology and engineering in the world, the views of stakeholders collected through various surveys and engagement activities as well as the need to align with the direction for the ongoing renewal of the school curriculum, the recommendations provided in the *Science Education Key Learning Area Curriculum Guide (Primary 1 - Secondary 3)* (2002) have been reviewed. Building on the strengths of Hong Kong students in science as revealed from international studies and local surveys, the curriculum emphases of the Science Education KLA have been updated, together with the aims, targets and objectives of science education for different key stages to highlight the key emphases of the ongoing renewal of the school curriculum, in particular STEM education. Given that elements of STEM education are already embedded in individual Key Learning Areas (KLAs) of Science Education, Technology Education and Mathematics Education of the school curriculum, there is a need to further strengthen the coherence and collaboration among KLAs. In this connection, the promotion of STEM education is a development focus to further enhance the quality and effectiveness of learning, hence enabling students to become more effective lifelong learners in the 21st century.

[1] STEM is an acronym that refers to the academic disciplines of Science, Technology, Engineering and Mathematics collectively.

The updates of the Science Education KLA Curriculum Guide are in line with the guiding principles for the ongoing renewal of the school curriculum and the updated learning goals of school education. More details are provided in the *Overview for Ongoing Renewal of the School Curriculum – Focusing, Deepening and Sustaining*.

The updated learning goals of school education, which continue to focus on promoting whole-person development and lifelong learning capabilities, are as follows:

Updated Seven Learning Goals of School Education
1. To be proficient in biliterate and trilingual communication for better study and life
2. To acquire and construct a broad and solid knowledge base, and to be able to understand contemporary issues that may impact on learners' daily lives at personal, community, national and global levels
3. To develop and apply generic skills in an integrative manner, and to become an independent and self-directed learner for future study and work
4. To be an informed and responsible citizen with a sense of national and global identity, appreciation of positive values and attitudes as well as Chinese culture, and respect for pluralism in society
5. To use information and information technology ethically, flexibly, and effectively
6. To understand one's own interests, aptitudes and abilities, and to develop and reflect upon personal goals with aspirations for further studies and future career
7. To lead a healthy lifestyle with active participation in physical and aesthetic activities, and be able to appreciate sports and the arts

Remarks: Please refer to Appendix 1 for details of the learning goals in primary education.

In gist, the following major areas of updates are put forth to reflect the changing contexts and education trends, and to provide suggestions for the development and implementation of the Science Education KLA Curriculum for now and in the five to ten years to come:

- Strengthening the ability to integrate and apply knowledge and skills among students through **STEM education**
- Emphasising the importance of **scientific literacy**, with an understanding of **nature of science** and a firm grasp of **science process skills** among students, for a strong foundation on scientific knowledge and skills
- Highlighting other key emphases of the ongoing renewal of the school curriculum, such as **generic skills**, **values and attitudes**, **Language across the Curriculum**

(LaC) and **information literacy (IL)** in planning and implementing the school-based science curriculum

- Emphasising the importance of **holistic curriculum planning** and the process of **P-I-E** (Planning-Implementation-Evaluation) for effective implementation of science education and STEM education in schools

- Promoting **e-learning** to motivate students' interest in learning science, enhance interaction and collaboration, and facilitate self-directed learning, with relevant learning and teaching activities in parallel to strengthen **information literacy** of students

- Stressing the continuous need to **cater for learner diversity** in science education with appropriate attention to students of different learning needs and styles, including students with special education needs (SEN) and those with special talents in science

2. What are the major updates?

2.1 Updating the curriculum aims

- To meet the challenges in the 21st century, Hong Kong students need to further strengthen their knowledge base, and the ability to integrate and apply knowledge and skills across different academic disciplines. Besides, they need to enhance their creativity, innovation and problem-solving skills to meet the challenges in the contemporary world of science and technology. Therefore, after consideration of the guiding principles and the seven updated learning goals of the ongoing renewal of the school curriculum, and the trend of development of science education, the curriculum emphases of Science Education have been updated as follows:

  - Strengthening students' ability to integrate and apply knowledge and skills (including hands-on skills)
  - Nurturing students' interest in science and related disciplines
  - Emphasising development of scientific thinking and problem solving skills among students
  - Fostering students to make informed judgements based on scientific evidence
  - Nurturing students to become self-directed learners in science
  - Catering for students with different needs and aspirations

  The emphasis "strengthening students' ability to integrate and apply knowledge and skills (including hands-on skills)" is realised through the promotion of STEM education in schools.

- The updated aims of science education are as follows.

Updated Aims of Science Education
1. Develop curiosity and interest in science
2. Develop the ability to make inquiries about science and solve problems
3. Acquire scientific knowledge and skills, and develop the ability to integrate and apply the knowledge and skills with other related disciplines
4. Become familiar with the language of science to communicate science-related ideas

Updated Aims of Science Education
5. Recognise the social, ethical, economic, environmental and technological implications of science, and develop an attitude of responsible citizenship and a commitment to promote personal and community health
6. Develop an understanding of the nature of science
7. Become a lifelong learner in science for personal development
8. Be prepared for further studies or future careers in scientific, technological and engineering fields

2.2 Updating the curriculum framework

- The curriclum framework of the Science Education KLA is updated in the following direction:

  (i) Maintaining the six strands of science education

  (ii) Highlighting the importance of scientific literacy (including science process skills and nature of science)

  (iii) Promoting STEM education – ability to integrate and apply knowledge and skills

  (iv) Including other updated key emphases of the ongoing renewal of the school curriculum

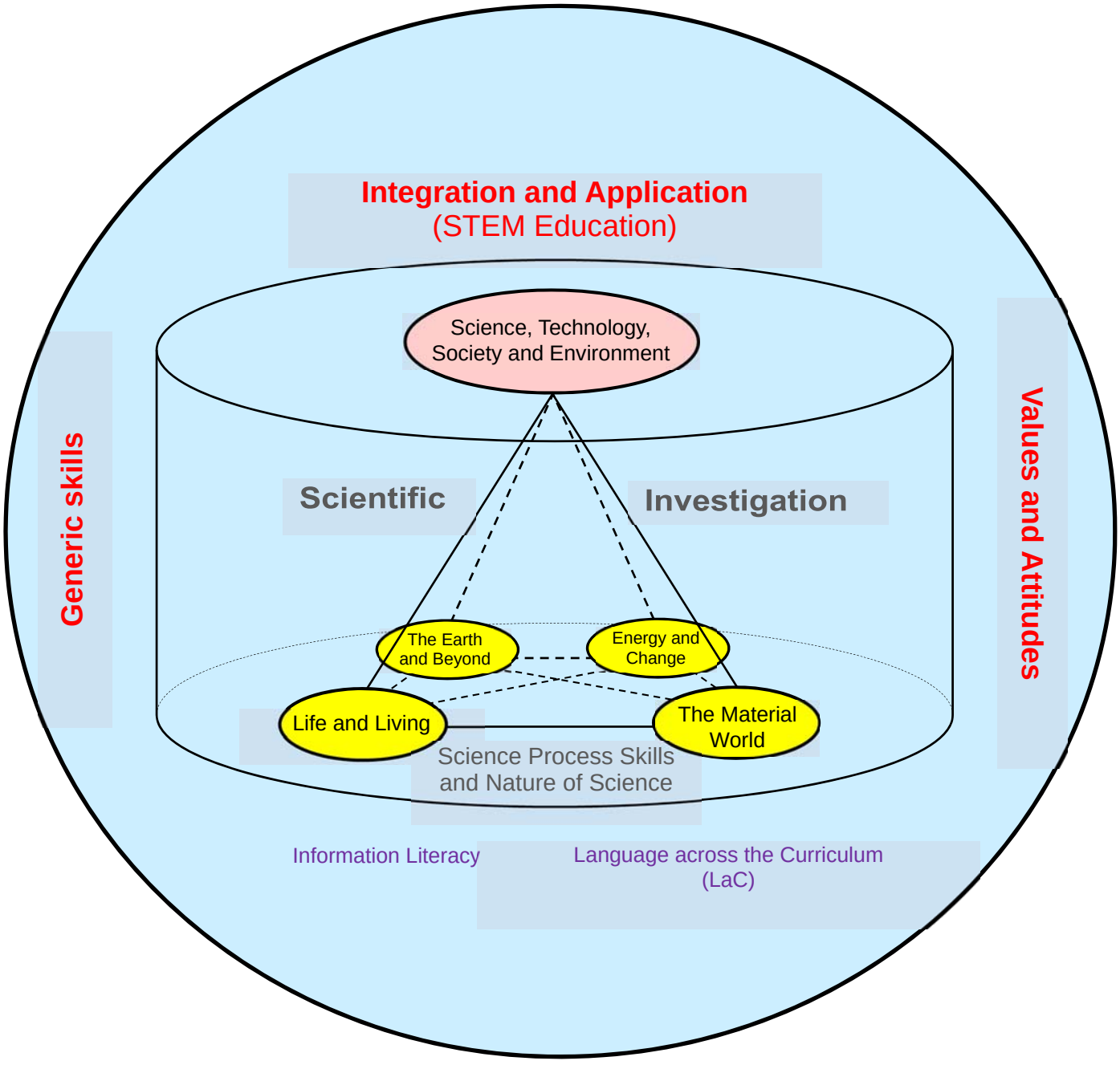
The diagram on the next page is a diagrammatic representation of the updated Science Education KLA curriculum framework.

(Please refer to diagram on the next page)

Diagrammatic Representation of the Science Education KLA Curriculum Framework

Science Education

Science education provides learning experiences for students to develop scientific literacy with a firm foundation on science, realise the important relationship between science, technology, engineering and mathematics, effectively master integration and application of knowledge and skills within and across KLAs, and develop positive values and attitudes for personal growth and for contributing to a scientific and technological world.



An open and flexible curriculum framework is adopted for the Science Education KLA with major learning elements of science arranged into **six strands.** STEM education and other key emphases of the ongoing renewal of the school curriculum are also included in the curriculum framework. Through appropriate connection and integration of the six strands, effective promotion of STEM education and infusion of positive values and attitudes, LaC and information literacy in curriculum planning, learning and teaching, and assessment, it is hoped that students could develop scientific literacy with a firm foundation in science, realise the important relationship between science, technology, engineering and mathematics, effectively master integration and application of knowledge and skills within and across KLAs, and develop positive values and attitudes for personal growth and for contributing to a scientific and technological world.

2.2.1 Maintaining the six strands of science education

- The six strands of science education, which encompass the major learning elements of science, are of equal importance:
  - Scientific Investigation
  - Life and Living
  - The Material World
  - Energy and Change
  - The Earth and Beyond
  - Science, Technology, Society and Environment (STSE)

  Their inter-relationship is illustrated in the diagram with a pyramid in which:

  - the strands of **Life and Living, The Material World, Energy and Change,** and **The Earth and Beyond** form the base of the pyramid. They represent the content areas of respective domains for developing students' understanding of relevant scientific concepts and ideas. These four strands of content are inter-connected and not isolated.

  - the strand of **Science, Technology, Society and Environment (STSE)** sits on top of the pyramid and links with the four strands of content areas, to show that STSE connections need to be addressed in each content area. Elements of STEM education that emphasise the ability to integrate and apply knowledge and skills are intrinsically embedded in the strand of STSE as technology and engineering are closely related. Besides, mathematics is implicitly included in the curriculum as it is an indispensable tool for learning of science.

- the strand of **Scientific Investigation**, through which students develop their **science process skills** and enhance their understanding of the **nature of science**, infuses into each of the other five strands.

2.2.2 Highlighting the importance of scientific literacy

- In the 21st century, along with globalisation and rapid technological development, even people outside the science professions have found the issues of their concerns are related to science. Therefore, it is necessary to promote scientific literacy through equipping students with knowledge of science, and facilitate their understanding of **nature of science** and acquisition of **science process skills**. Acquisition of scientific literacy would enable students to participate intelligently in public discourse and debate about important issues that involve science, technology, society and environment. A scientific literate person possessing a scientific habit of mind is able to apply science knowledge and process skills to tackle issues and problems related to their daily life and the natural world.

- **Science process skills** are the skills involved in the process of performing scientific investigations and they form the foundation for scientific methods. It is essential for students to master science process skills in studying science. The development of various science process skills enables students to solve problems logically and sensibly. It would not only facilitate students' understanding of the nature of science but also help them develop positive values and attitudes towards science.

  The essential science process skills are:

  - Observing
  - Classifying
  - Designing investigations
  - Conducting practical
  - Inferring
  - Communicating

- **Nature of science** is an essential learning element in the science curriculum. It is about the belief and attitudes towards the knowledge about the natural world, the methods and processes through which scientific knowledge is acquired, and the socio-cultural and historical influences involved. The study of the nature of science could increase students' interests, enhance their understanding of scientific knowledge, and facilitate them to make informed decisions about science-related issues in their daily life.

2.2.3 Updating the Science (S1-3) curriculum

- The Science (S1-3) curriculum is reviewed along the following direction:

  (i) To fine-tune and update the curriculum content

  (ii) To nurture students' interest in science

  (iii) To help students build a solid and balanced foundation in science

  (iv) To strengthen the bridging between junior and senior secondary science curricula

- Major updates on the curriculum are as follows:

  - 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 experiences (e.g. projects, design-and-make activities).

2.2.4 Updating the primary General Studies curriculum

- Major updates on primary General Studies curriculum are as follows:

  - 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)

2.2.5 Promoting STEM Education in Schools

- In the local curriculum context, STEM education is promoted through Science, Technology and Mathematics Education KLAs. The aim of promoting STEM education in schools is 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 with specific objectives including:

  - 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

- 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.

- 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.

More details about the guiding principles and strategies for promoting STEM education in schools are elaborated in the document, namely *Overview on Promotion of STEM Education – Unleashing Potential in Innovation.*

2.2.6 Other key emphases of the ongoing renewal of the school curriculum

- **Refined generic skills**

Nine generic skills have been identified as essential for student learning for the 21st century in the school curriculum since 2001. Based on past experience of implementing the reform, as well as dynamic changes in society and recent research, the nine generic skills are presented in three clusters, namely "basic skills", "thinking skills" and "personal and social skills" for better understanding and integrative application:

Basic Skills	Thinking Skills	Personal and Social Skills
Communication Skills	Critical Thinking Skills	Self-management Skills
Mathematical Skills[1]	Creativity	Self-learning Skills[2]
IT Skills	Problem Solving Skills	Collaboration Skills

Remarks: [1]Numeracy Skills and [2]Study Skills were used respectively in *Learning to Learn: The Way Forward in Curriculum Development* (2001)

The Science Education KLA provides meaningful contexts for the development of generic skills, alongside science process skills, through appropriate learning and teaching activities and specific topics. Schools should plan science-related learning and teaching activities in a holistic manner whereby the cluster of skills above would be suitably and effectively applied and developed among students. For examples, learning and teaching activities such as scientific investigations, experiments, field work, group discussion, project learning and debates on science-related issues, which allow students to be actively engaged in the learning process, are effective ways to motivate learning and to develop generic skills.

- **Promoting values education**

  Values education / cultivation of positive values and attitudes is an integral part of the school curriculum and is implemented through different components in KLAs, moral and civic education, cross-curricular learning opportunities and life-wide learning experiences. According to the framework for moral and civic education provided by the Curriculum Development Council in 2008, seven priority values and attitudes, which reflect both Chinese and Western cultures/values and address students' and societal needs, were identified as of vital importance for students' whole-person development. They are perseverance, respect for others, responsibility, national identity, commitment, integrity, and care for others. Schools are recommended to implement values education and cultivate positive values and attitudes covering personal, family, community, national and global domains as well as values in accordance with the mission and contexts of their schools. Schools should adopt a whole-school approach to curriculum planning that closely connects with the KLAs/subjects, and design relevant learning experiences for students to nurture their positive values and attitudes.

  In Science Education KLA, values education can be carried out through relevant topics and appropriate learning and teaching activities that help students apply and reflect on positive values and attitudes, or introducing different situations in which students are required to understand the issues from different perspectives, analyse them in a rational and objective manner, and adopt positive values and attitudes as the guiding principles to make judgment and decisions. For example, the following values and attitudes could be permeated in the learning and teaching of science and in STEM-related activities:

  - Curiosity
  - Critical reflection
  - Open-mindedness
  - Respect for evidence
  - Willingness to tolerate uncertainty
  - Appropriately valuing the suggestions of others
  - Caring for the living organisms and their environment
  - Committed to sustainable development of the environment

- **Language across the Curriculum (LaC)**

  Literacy refers to the ability to read and write effectively to achieve the desired goals or outcomes and develop one's knowledge and potential. Helping learners master the literacy skills, i.e. reading and writing skills, is central to language learning at school level. It is essential that literacy be also developed in different KLAs which provide the contexts for learners to apply their literacy skills to construct knowledge and to facilitate their development into lifelong learners.

  With the rapid development of information technology and the social media, literacy has taken on a new meaning. Learners need to be equipped with new literacy skills to process and create multimodal texts in which messages are conveyed through different forms (e.g. images, animations and sounds).

  The Science Education KLA provides authentic contexts for learners to apply their literacy skills to construct knowledge and to facilitate their development into lifelong learners. The Language across the Curriculum (LaC) approach, which integrates language learning and content learning, can be adopted for learners who need to learn science through English and Chinese, and to explore knowledge and develop skills in a comprehensive and integrative manner. While English/Chinese teachers focus on helping learners to master the accurate use of the language (e.g. vocabulary and grammar) as well as to recognise the importance of coherence, cohesion and appropriacy in texts, science teachers can facilitate the transfer of the English and Chinese knowledge and skills by emphasising the use of relevant language features for presenting the subject content during the learning and teaching process, and providing opportunities for learners to apply relevant English/Chinese knowledge and skills to demonstrate their understanding of the science content through completing the Science Education KLA-based assignments or tasks.

  Science teachers can collaborate with English/Chinese teachers to facilitate LaC through

  - identifying the entry points, setting realistic goals and drawing up a plan or schedule of work to facilitate transfer of English/Chinese knowledge and relevant language skills
  - developing learning, teaching and assessment materials and activities that connect students' experiences
  - identifying a common topic between the Science Education KLA and English/Chinese Language for learners to read about and discuss, and assigning learning activities or tasks outside classroom to broaden learners'

experience

- providing learners with exposure to the text types or genres commonly found in the Science Education KLA (e.g. procedural accounts)
- teaching KLA-specific language features and rhetorical functions (e.g. comparing and contrasting, giving explanations) explicitly to facilitate the completion of the Science Education KLA-based tasks

Some examples that can enhance reading and writing competence of students in science are as follows:

	Strategies/Tasks
Reading	• Reading to learn - Using graphical organisers - Unpacking and packing science ideas and language focus
Writing	• Learning to write - Writing laboratory safety rules - Writing experimental procedures - Describing observations - Giving a full account of experimental results - Writing investigation reports

- **Strengthening Information Literacy (IL)**

Information Literacy is an ability and attitude that would lead to an effective and ethical use of information. It aims to help students (i) identify the need for information, (ii) locate, evaluate, extract, organise and present information; (iii) create new ideas; (iv) cope with the dynamics in our information world; and (v) use information ethically and refrain from immoral practices such as cyber bullying and infringing intellectual property rights. The Four Key Tasks will provide opportunities for students to develop and apply IL.

Student learning requires the use of IL whenever necessary. The Science Education KLA has a role to play in developing students' IL. Learning of science usually requires the use of IL. For example, scientific investigation and STEM-related project learning usually involve data collection, organisation, analysis, interpretation and reporting, which are essential skills related to IL. Infusion of IL in the primary General Studies and secondary science subjects in schools would enhance students' ability to apply knowledge and skills, and facilitate them to gain

more benefits in learning of science, and better equip them to live in the contemporary world as informed and responsible citizens.

2.3 Pedagogies (including e-learning)

2.3.1 Effective learning and teaching strategies for science

- Owing to students' diverse needs and the specific targets in different learning contexts, teachers need to have a thorough understanding of different pedagogical approaches, to design and provide meaningful learning experiences. In general, pedagogical approaches can be categorised in accordance with the following three notions of learning and teaching: learning as a "product" of "direct instruction", learning as a "process" and teaching as "inquiry", and learning and teaching as "co-construction". The key principle for choosing suitable pedagogical approaches is "fitness for purpose". The different approaches can complement with one another, and no single pedagogical approach may serve all learning targets and students' diverse needs.

- To enhance the learning of science and to make science interesting, relevant and important to students, learning and teaching strategies such as practical work, investigation, discussion, role-play, debate, context-based learning, problem-based learning and project learning could be adopted. When selecting a pedagogical strategy, teacher should note the importance of the alignment between the curriculum, pedagogy and assessment in bringing about effective learning and teaching.

2.3.2 Approaches for organising learning activities on STEM education

- STEM-related learning activities should bridge across the curricula of the KLAs of Science, Technology and Mathematics Education to enhance students' interest and innovation, and to develop their ability to integrate and apply knowledge and skills within and across KLAs. When planning and designing these learning activities, science teachers should closely collaborate with teachers of the Technology and Mathematics Education KLAs to facilitate students' integration and application of knowledge and skills. Depending on the school context, students' interests and abilities, and teachers' expertise, two different approaches to provide STEM-related learning activities for students are recommended.

Approach One	<u>Learning activities based on topics of a KLA for students to integrate relevant learning elements from other KLAs</u> In this approach, the learning activity is based on a particular topic of a subject of a KLA, e.g. Science Education. Relevant learning elements are drawn from the other KLAs, e.g. Technology and/or Mathematics Education, to allow students to integrate and apply the knowledge and skills they have learnt. For example, in the science topic of 'Force and Motion', students study the scientific theories and grasp the knowledge related to the launching of a rocket. Related learning elements (e.g. computation, algebra, design and make, choice of materials for model making) from Technology and Mathematics Education KLAs, could be incorporated and used to enrich the learning activity and also the learning experience of students.
Approach Two	<u>Projects for students to integrate relevant learning elements from different KLAs</u> In this approach, project learning or other STEM-related learning activities is/are arranged for students to integrate the related learning elements from the Science, Technology and Mathematics Education KLAs. Students are assigned an authentic problem to tackle. During the process, students need to confront the issues, and to solve daily life problems with practical solutions and innovative designs. Relevant learning elements and experiences from different KLAs have to be brought in by students themselves. To solve the problem, they would need to integrate the knowledge and skills they have learnt from different subject disciplines and apply them flexibly in a real context.

**A diagrammatic illustration of the two approaches is shown in Appendix 2.*

- Problem-based learning (PBL), context-based learning and project learning are deemed suitable learning and teaching strategies for arranging learning and teaching activities for STEM education. The uses of authentic contexts and solving daily life problems could highlight the relevance and importance of science to students, and enhance students' awareness of the interconnections among science, technology, engineering, society and the environment.

2.3.3 e-Learning in Science Education

- e-Learning refers to an open and flexible learning mode involving the use of the electronic media, including the use of digital resources and communication tools to achieve the target learning objectives. The essence of e-learning is to enhance learning and teaching effectiveness in schools and helps develop students' necessary qualities (e.g. self-directed learning) for the 21st century. Teachers may develop a repertoire whereby e-learning may help enhance, modify and complement some existing learning and teaching strategies or break new ground in pedagogy.

- e-Learning can be adopted in the Science Education KLA through:

  - Using the Internet as a resource of data and information.
  - Using interactive CD-ROMs or online materials to support the learning of specific topics at students' own pace.
  - Making use of animations and simulation to help students visualise natural phenomena and processes, and grasp abstract concepts.
  - Using video-imaging devices for experiments or demonstrations, so that students can observe/investigate the processes in greater details.
  - Using data-loggers to conduct experiments.
  - Using a flipped-classroom approach by recording and uploading short video clips to the school's intranet or the Internet so that students can watch the clips and prepare for the lesson beforehand. Teachers could then spare the lesson time for more engaging learning activities, e.g. group discussion and solving problems.
  - Using mobile devices such as mobile phones and tablet computers and apps inside and outside the classroom for interactive learning and to extend science learning beyond the classroom.
  - Using online platforms for discussion, dissemination of resources and collaborative learning.
  - Utilising on-line assessment tools such as multiple-choice question banks and also instant response devices to provide prompt feedback of student learning, so that appropriate follow-up actions/support could be rendered by teachers.

2.3.4 Catering for learner diversity

- In every school, there are students with different learning styles, needs, interests and abilities. For effective learning and teaching, teachers should always attend to learner diversity and take appropriate action to help different students learn

better. Teachers should equip themselves with a repertoire of tactics, such as flexible grouping, remedial and extension activities, and varying the curriculum content, pedagogy and the assignments according to the abilities, needs and interests of their students. Schools should groom students with a special talent in science and STEM disciplines, and develop their potential. Enrichment activities and additional tasks of challenge should be devised for these students. In addition, arrangements can be made for the more able students to participate in a variety of local and/or overseas learning programmes or science competitions.

2.4 Assessment

2.4.1 Different modes of assessment for different purposes

- Assessment is in general divided into two modes: summative and formative, which are both valued in science education. There are two different approaches for formative assessment, namely **assessment for learning** and **assessment as learning**.

- **Assessment for learning** can be achieved by assessing students on a continuous basis with different methods such as classroom observation, class activities, assignments, projects, practical tests and written quizzes. It aims at identifying students' strengths and weaknesses and providing quality feedback for students to understand the progress of their learning, what they have attained, and what is expected to improve their learning. Assessment for learning also provides teachers with evidence about the students' learning, enabling them to timely review their curriculum planning and teaching practices.

- **Assessment as learning** engages students in reflecting and monitoring their progress of learning. This can be achieved by self-assessment and peer assessment. Self-assessment involves students' thinking about what and how they are learning during the process of learning. This provides feedback to students to self-reflect and to adjust their learning strategies. On the other hand, peer assessment involves students in evaluating the performance and the quality of work by their peers based on a set of predetermined criteria prepared by teachers. Through receiving and providing feedback, students gain benefits in their learning from peers.

2.4.2 Assessment strategies for Science Education KLA

- Common assessment strategies usually used by science teachers include paper and pencil tests, written assignments, oral questioning, observation, practical assessment, project work, e-assessment and portfolios. Science teachers should

adopt suitable assessment strategies according to the needs of their students, nature of the tasks and the learning objectives.

2.4.3 Assessment for STEM-related learning activities

- One of the objectives of STEM education is to strengthen students' ability to integrate and apply knowledge and skills from different STEM disciplines. Assessment for STEM-related learning activities should therefore cover knowledge, skills and attitudes, to reflect the performance and capability of the students as independent/collaborative learners.

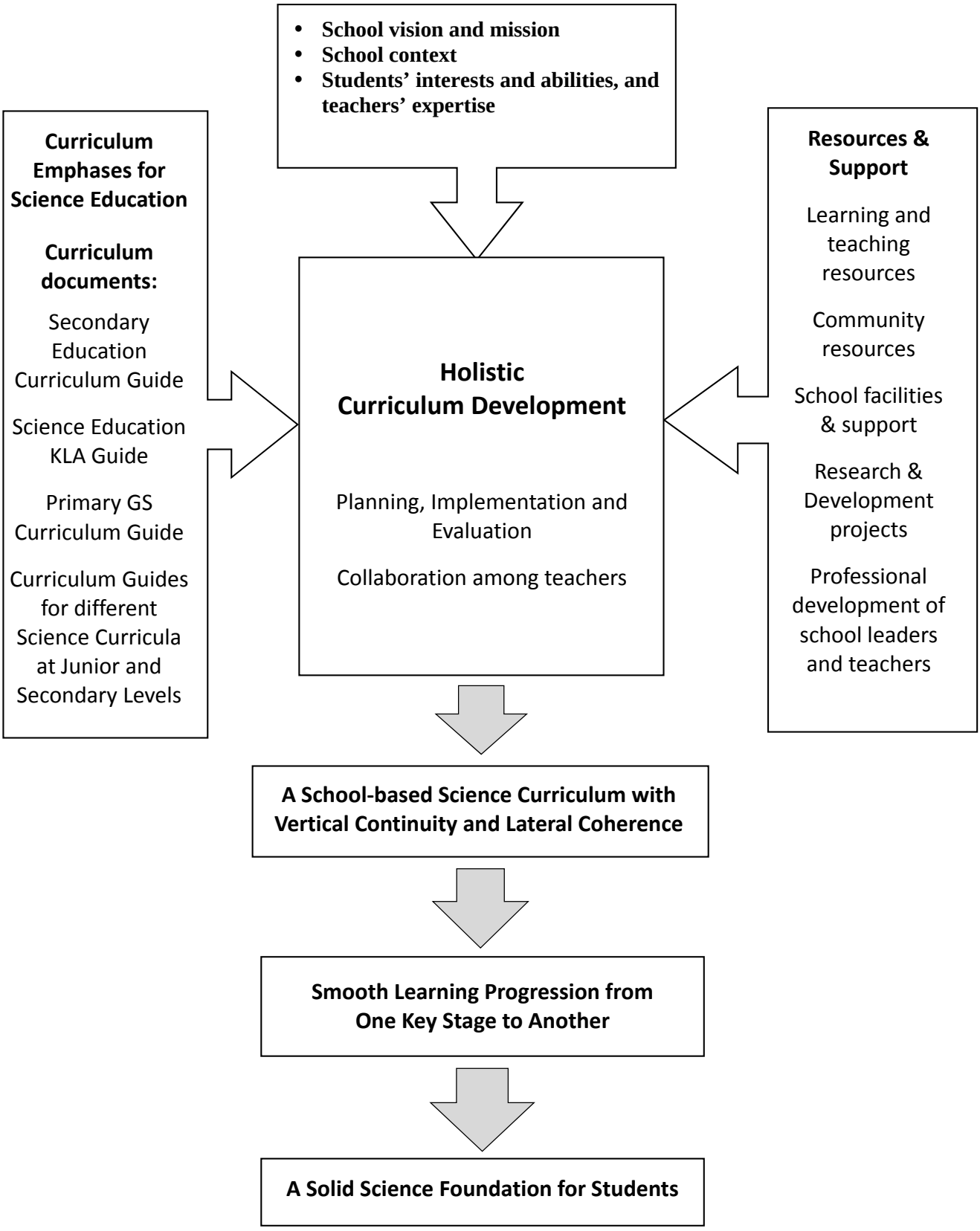
- At school level, "assessment as learning" and "assessment for learning" in formative assessment should be adopted to collect evidences of student learning in both the knowledge and skill domains. Integration and application of knowledge and skills, problem solving and creativity should be included, where appropriate, in the assessment according to the nature and progress of the STEM-related learning activities. During the course, various assessment strategies, such as oral questioning and class discussion, observation, self and peer assessments, and presentation of relevant designs/plans for the project, can be adopted. These assessment strategies allow teachers to provide timely and constructive feedback to students, and therefore guide them to monitor and reflect on their own learning. By the end of the learning activities, summative assessment strategies, such as assessing students' final products or written reports, can be used to provide comprehensive information about what students have achieved.

2.5 Curriculum management and planning of learning time

The diagram on the next page shows the major considerations for planning holistic curriculum development in Science Education KLA.

(Please refer to the diagram on the next page)

Holistic Curriculum Development in Science Education KLA



2.5.1 Holistic curriculum development in Science Education KLA

- Holistic curriculum planning is recommended for school-based curriculum development to ensure vertical continuity and lateral coherence in the Science Education KLA. Schools have to base on the curriculum guides of Science Education KLA and those of other KLAs, to build a balance and solid science foundation in students with smooth transition and progression between key stages. Schools are advised to take into consideration of the interests and abilities of their students and the expertise of their teachers when setting the goals and plans for school-based curriculum development. A collaborative culture among teachers would be established in schools, through participating in the curriculum development process, with the support from laboratory technicians. Besides, schools are also encouraged to make flexible use of time, and spaces and resources inside and outside schools according to the context of the local community. The PIE (Planning-Implementation-Evaluation) mechanism can be adopted for the evaluation of school-based curriculum development.

2.5.2 Strengthening integration and application of knowledge and skills with collaboration among Science, Technology and Mathematics Education KLAs

- Science, Technology and Mathematics Education KLAs have an important role to play in the promotion of STEM education. Schools can strengthen students' ability to integrate and apply knowledge and skills, as well as development of positive values and attitudes, through:

  - providing a favourable environment with ample opportunities for students to integrate and apply knowledge and skills of different disciplines during the process of learning
  - holistic curriculum planning with due consideration of providing different scenarios for students to integrate and apply knowledge and skills across disciplines
  - making use of KLA-based and cross-disciplinary learning activities of different nature, such as project learning, case-based/problem-based learning and mathematical modeling, to provide meaningful contexts that are closely geared to daily life to engage students in problem solving. The activities may include scientific investigations, design-and-make tasks, etc. that can foster integration and application of knowledge and skills of different disciplines
  - encouraging and supporting students to participate in STEM-related competitions and other fun-filled learning activities arranged by different

local and overseas organisations wherever appropriate, as well as those regularly organised by local museums and professional bodies

- promoting collaboration among teachers at school level in planning and organising cross-disciplinary learning activities

2.5.3 Planning of learning time

- In planning the time allocation for the primary General Studies curriculum and the different science curricula at junior and senior secondary levels, schools should refer to the respective curriculum guides for the recommended lesson time. To align with the Curriculum Development Council's recommendation, the EDB advises schools to allocate adequate but not excessive lessons to each KLA and subjects taking into consideration the learning needs of their students and their unique contexts at each key stage.

- The proportion of lesson time recommended for primary General Studies, Science (S1-3) and other senior secondary science elective subjects is as below.

  - General Studies at primary level: 12-15%
  - Science (S1-3) at junior secondary level: 10-15%
  - Each of the science elective subjects at senior secondary level: 10-15%

- Schools are also encouraged to use the designated "flexible time" to conduct cross-curricular learning activities, e.g. values education, Basic Law education, Reading across the Curriculum and STEM-related activities, to ensure the whole-school curriculum is broad and balanced, in terms of promoting whole-person development. The flexible time for the primary and junior secondary levels is 19% and 8% respectively in each key stage. As for the senior secondary level, 10-15% of time allocation is set aside for Other Learning Experiences (OLE). Schools should give due consideration to the overall planning and co-ordination among different KLAs and subjects with flexibility to organise OLE inside and outside the school timetable.

3. What are the supporting strategies?

3.1 Learning and teaching resources

- Textbooks are not the only learning and teaching resources to support science education. Schools are recommended to make good use of existing resources, such as equipment in science laboratories and other special rooms, IT facilities, audio & visual aids, library books, learning and teaching resources packages, etc., for supporting the implementation of the curricula of Science Education KLA and for promoting STEM education. Some schools have set up their own eco-gardens, solar panel/weather monitoring systems, star glazing platforms, etc. which are all useful resources to enrich the learning experiences of students in science and technology. The school libraries serve as a resource bank which provides access to timely information in various formats, such as reference books, journals and multimedia productions, to support learning and teaching activities of science and STEM-related disciplines both inside and outside the classrooms. Teachers and students may also use the learning and teaching resources developed and offered online by the EDB. Many of these are of cross-disciplinary nature and closely related to daily life applications of science and technology. They can be used for teachers' and students' reference when schools try to promote STEM education. For easy access of the resources by teachers and students, the EDB has set up a portal at the Hong Kong Education City, namely "EDB One-stop Portal for Learning and Teaching Resources" (www.hkedcity.net/edbosp), for users to access the many up-to-date web-based resources that have been developed to support learning and teaching of science and other STEM-related disciplines. To support schools in promoting STEM education, the EDB will further enrich the resources for schools' reference.

- The implementation of science education and STEM education are not confined within the school campus. Resources available from other government departments, non-government organisations, tertiary institutions, professional bodies, etc. could be utilised to facilitate life-wide learning of science and technology, and enrich the learning experiences of students. Community resources useful for science education/STEM education include many accessible public facilities or sites such as science museums, science/technology centres or nature reserves, which provide valuable opportunities for students to investigate and explore, to create and innovate, and to interact and collaborate. Besides, many science exhibitions and competitions on various themes are available from different organisations for students' participation. Through visits, field trips, surveys, attending workshops, etc., students would not only develop their interest in science, but also build up their competence to apply knowledge and skills of

different subject disciplines to solve authentic problems. An updated list of community resources useful for science education, and STEM education as well, will be provided for schools' reference.

3.2 Partnerships with key players in the community

- All along, EDB has been engaging different stakeholders in the promotion of student learning in science/STEM areas, and there is a need to further strengthen the partnerships with them. The communication with local curriculum advisory committees, as well as the school sector, for facilitating student learning in the KLAs of Science, Technology and Mathematics Education will be further enhanced.

- In liaison with academics and practitioners who are specialised in various science, technology, engineering and mathematics fields, the EDB will explore the feasibility of collaborating with tertiary institutions and specialists in organising teacher training programmes and student learning activities.

- The EDB will continue to strengthen the partnerships with professional bodies (e.g. Hong Kong Association for Science and Mathematics Education), government departments (e.g. Leisure and Cultural Services Department, Agriculture, Fisheries & Conservation Department) and also government related/non-government organisations (e.g. Hong Kong Science Park, British Council, Hong Kong Federation of Youth Groups), in fostering synergy within the community for promoting science education/STEM education in schools.

3.3 Professional development of school leaders and teachers

- While schools are generally aware of the capacity building needs of their teachers and staff development programmes are regularly arranged to address the needs of the teachers, the EDB will continue to support schools and teachers by organising professional development programmes (PDPs) to strengthen the professionalism of teachers and school leaders. Besides, relevant PDPs are provided for laboratory technicians.

- To enhance the professional capacity of curriculum leaders and teachers in implementing science education/STEM education holistically and effectively at school level, the EDB is taking steps in strengthening the relevant PDPs:

    - To organise symposia for curriculum leaders. These signature events aim to serve as a hub to engage stakeholders for the promotion of STEM education among local schools.

- 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 to integrate and apply knowledge and skills within and across disciplines. Seminars and workshops on enriching teachers with the most up-to-date knowledge on STEM-related fields will continue to be organised.
- 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)).
- 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.

4. Frequently Asked Questions

Q 1: **What is Learning to Learn 2.0?**

A 1: Learning to Learn 2.0 is referred as the ongoing curriculum renewal of the Learning to Learn curriculum reform implemented since 2001 in response to the local and global contextual changes in economic, scientific, technological, social and political aspects. With a view to keeping our school education abreast of the times and maintaining the global competitiveness of our students, it is necessary for the Hong Kong school curriculum to embark on the next cycle of updating and renewal, which aims to deepen and sustain the accomplishments and to focus on the possible areas for curriculum planning under Learning to Learn 2.0. Ongoing engagement of stakeholders through multiple channels has been conducted in setting the direction for the ongoing curriculum renewal.

Q 2: **Why is it necessary to update the Science Education Key Learning Area Curriculum Guide (Primary 1 – Secondary 6)?**

A 2: The Science Education KLA Curriculum Guide has been updated to highlight, as one reason, the importance and implications of STEM education to help students tackle the challenges in the 21st century. Its coverage has been extended to the senior secondary level. While promotion of STEM education is the focus of the Science Education KLA, other key emphases of the ongoing renewal of the school curriculum including the refined generic skills, promotion of values education, Language across the Curriculum, information literacy, etc. will also need to be infused. Science-specific emphasis such as scientific literacy, science process skills and nature of science are elaborated more clearly in the updated Curriculum Guide to enhance the development of science education in schools. For effective implementation of STEM education and other relevant elements, appropriate holistic curriculum planning at the school level and also the KLA level is indispensable and advices are provided in the Curriculum Guide for reference of schools on planning, implementation and evaluation of science education and STEM education in schools.

Q 3: **Would there be a new STEM curriculum at primary/secondary levels?**

A 3: No. Relevant learning elements of STEM education are embedded in subjects of the Science, Technology and Mathematics KLAs. The emphasis of STEM education is on enriching and strengthening the learning and teaching activities such as project learning and case-based/problem-based learning so that, through solving authentic problems with practical solutions and innovative designs, students are provided with more opportunities to integrate and apply the knowledge and skills from the KLAs of Science, Technology and Mathematics Education. It is hoped that with the learning experiences of STEM-related activities, students can enhance their interest and knowledge in different STEM fields, and develop their creativity, collaboration and problem solving skills, which foster innovation and entrepreneurial spirit as required in the 21st century. For effective implementation of STEM-related activities, holistic curriculum planning at both the school level and KLA level is necessary. Collaboration among teachers of different KLA has to be strengthened.

Q 4: **In promoting STEM education, what kinds of support will be provided by the EDB? How may schools acquire additional resources for promoting STEM education?**

A 4:

- **Teachers' professional development and support**

  The EDB will continue to organise PDPs to enhance teachers' professional capacity in relation to the promotion of STEM education. Further to the symposium held in July 2015, two events of another symposium cum consultation briefing were organised in early November to enhance teachers' understanding of STEM education. In the next three school years, PDPs will continuously be organised for panel heads and teachers, to facilitate teachers in using appropriate strategies to strengthen the ability of students to integrate and apply the knowledge and skills of different disciplines. More seminars and workshops will continue to be organised to enrich teachers with the most up-to-date knowledge on STEM-related fields. At the same time, different platforms will be used to foster sharing of professional knowledge. Furthermore, opportunities will be provided for teachers to expose themselves to cutting edge development in science and technology fields through exchange with academics/partners in the territory and from the Mainland and overseas.

- **Programme to nurture students' capability in STEM fields**
  The EDB will organise an education fair on STEM-related disciplines in early 2016 to showcase students' achievements in learning. This event will enhance students' interest and creativity in science, technology and mathematics, and help them pave the way for future studies and careers in related areas.

- **Learning and teaching resources**
  The EDB will continue to develop learning and teaching resources, which are to be uploaded to the EDB One-stop Portal for teachers' reference. The resources include information about STEM-related learning activities and projects, good practices from schools, information about life-wide learning activities and other related reference materials.

- **Using community resources**
  The EDB will continue to liaise with academics and practitioners specialised in various science, technology, engineering and mathematics fields, and to explore feasibility of collaborating with tertiary institutions and specialists in organising training programmes and student learning activities. Besides, the EDB will continue to strengthen the partnerships with professional bodies, and other government and non-government organisations in fostering synergy within the community for the promotion of STEM education among schools.

- **Other resources**
  Schools can acquire additional resources from the Quality Education Fund (QEF), Professional Development Schools Scheme (PDS) of Education Development Fund (EDF), etc. to promote and enhance school-based programmes related to STEM education.

Appendix 1

The seven learning goals which students are expected to achieve upon completion of primary education as listed in the *Basic Education Curriculum Guide – To Sustain, Deepen and Focus on Learning to Learn (Primary 1-6)(BECG) (2014)* are provided in the following table for reference

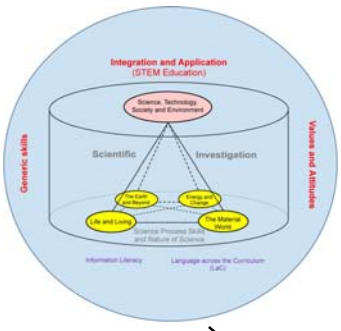
The Seven Learning Goals in BECG (Primary 1-6)	Details
1. Responsibility	• Know how to distinguish right from wrong, fulfil their duties as members in the family, society and the nation, and show acceptance and tolerance towards pluralistic values;
2. National Identity	• Understand their national identity and be concerned about society, the nation and the world, and to fulfil their role as a responsible citizen
3. Habit of Reading	• Develop an interest in reading extensively and cultivate a habit of reading
4. Language Skills	• Actively communicate with others in English and Chinese (including Putonghua);
5. Learning Skills	• Develop independent learning skills, especially self-management skills and collaboration skills
6. Breath of Knowledge	• Master the basics of the eight Key Learning Areas to prepare for studying in secondary schools
7. Healthy Lifestyle	• Lead a healthy lifestyle and develop an interest in aesthetic and physical activities and an ability to appreciate these activities

Source: BECG https://cd.edb.gov.hk/becg/english/chapter1.html#s1.7

Appendix 2

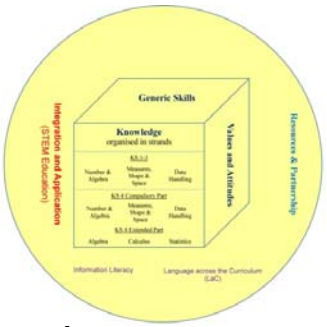
APPROACHES FOR ARRANGING STEM-RELATED LEARNING AND TEACHING ACTIVITIES

Science Education KLA



Technology Education KLA

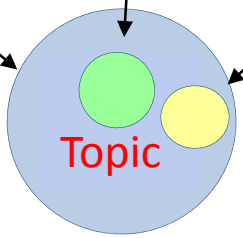
Mathematics Education KLA



Select a topic from a KLA

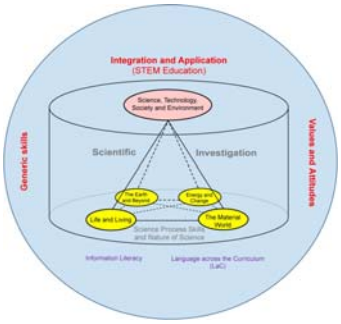
Learning elements

Learning elements



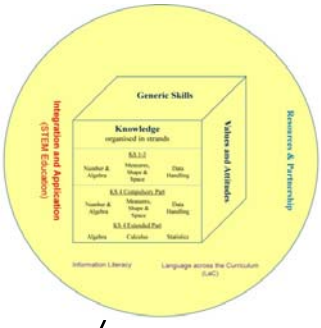
APPROACH ONE

Science Education KLA



Technology Education KLA

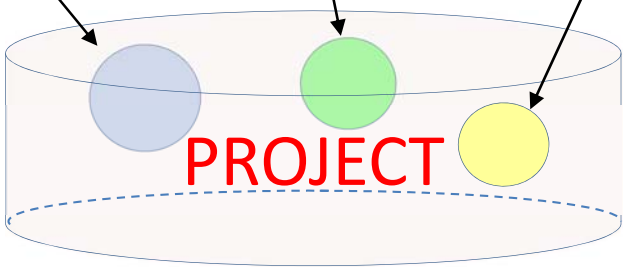
Mathematics Education KLA



Learning elements

Learning elements

Learning elements



APPROACH TWO

Appendix 3

Example 1

Integrating an e-Learning Strategy into Practical Enquiry in a Laboratory

Level: Senior Secondary Curriculum: Chemistry

Emphasis: e-learning, practical enquiry

Aims: (a) To facilitate students to actively participate in practical activities
(b) To promote collaboration among students

A chemistry teacher, who is working in a school with a good WiFi connection to the Internet[2], explains to his students in laboratory how to carry out the four different practical learning tasks on the topic "Redox reaction" using a brief talk and a tailored-made experiment manual. Following the routine practice, students organise themselves into different study groups, with each consisting of 4 or 5 students, to complete the tasks. Four laboratory benches equipped with apparatus and materials required for the tasks are made available by the laboratory technician. Each group of students is required to complete the practical tasks and video-record the whole processes with a narration.

In each group, students read the experiment manual, discuss how to allocate duties and then carry out the practical tasks in a collaborative way. A student takes up the role of a video camera operator with a tablet computer (provided by the school) while another student serves as a narrator. The rest work together to prepare the chemicals and handle the apparatus required for the task. After a brief group discussion, all the students start to carry out the tasks assigned. The whole process is video-recorded with narration. The teacher moves around to different groups to provide learning support wherever necessary. Soon after completion of the practical tasks, students start to upload the video clips to a learning management system (LMS)[3], which is provided by a local tertiary institute.

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[2] The school is one of the first 100 public sector schools participated in the "Support Scheme for e-Learning in Schools" (EDB, 2014).
(http://www.edb.gov.hk/en/edu-system/primary-secondary/applicable-to-primary-secondary/it-in-edu/supportscheme/index.html)

[3] MDM Partnership Programme (HKU, 2015) (URL: http://elearning.eee.hku.hk/)

When all groups have completed the practical tasks, the teacher leads a post-enquiry debriefing to consolidate students' learning in the lesson. The teacher first retrieves the video clips produced by the students from the LMS, and then launches an interactive question and answer session. During the dialogue, the teacher provides quality and timely feedback to the students. After discussion, students are encouraged to work collaboratively to review their observations and answers with the aid of the video clips in the LMS. Finally, all students attempt to complete their reports individually. By the end of the lesson, the teacher encourages his students to review all the video clips again in the LMS at any time after the lesson whenever necessary.

Remarks: This lesson requires IT resources and support, for example, a good Internet connection, several tablet computers and a LMS, as well as the support from a laboratory technician. The following points are considered to be important success criteria and features that are conducive to students' learning.

- The teacher has developed a good lesson plan.
- The students engage actively in doing, recording and narrating the experiments, and engaging in quality dialogue in the debriefing.
- The teacher provides quality and timely feedback to students by referring to the video clips produced by the students and saved in the LMS.
- The students can access all the video clips in the LMS at any time and any place again via the Internet.

Example 2

Developing Ability to Integrate and Apply Knowledge and Skills through Project Learning

Level: S1-3 Curriculum: Cross KLAs

Emphasis/Aim: To develop students' ability in integrating and applying knowledge and skills across the science, technology and mathematics disciplines

KLA	Learning Elements
Science Education	• Common food substance • Function of food substance • Food pyramids • Balanced diet • Healthy lifestyles
Technology Education	• Dietary goals and eating habits • Principles and skills in food preparation • Use of computer networks
Mathematics Education	• Compute and interpret data • Diagram and graphs

Task: Design a healthy diet menu for a school lunch box supplier

- In this activity, teacher adopts a cross-disciplinary approach that requires students to integrate and apply the knowledge and skills from Science, Technology and Mathematics Education KLAs. The project itself is arranged as an independent activity. Learning elements from different KLAs would be drawn during the course when the project is conducted.
- The teacher chooses an authentic problem that most students are concerned about. Quite often, there are students complaining about the taste, quality and quantity of the lunch boxes provided by the lunch box supplier. On the other hand, the nutritional values of the lunch boxes are an issue that may affect the health of teenagers. Therefore, teachers can request students to conduct a project on designing a healthy diet menu for use by the lunch box supplier, in order to meet the needs of students in acquiring healthy and quality food within the school.
- Starting from the essential question, plenty of learning opportunities can be arranged for students to construct, integrate and apply knowledge and skills from different KLAs. Students can use IT skills to search information about food and diet, including the functions of food substances, nutritional values, recommended daily intake, etc. Students can apply computational skills to calculate and analyse the nutritional values of different food substances. Students can also conduct a survey to collect information about the food preference of their fellow students, and prepare food samples for tasting. After proper analysis, students can submit the healthy diet menu that have agreed among themselves to the school lunch box provider for reference.
- During the process, teachers should provide proper guidance, timely feedback, resources and support to their students whenever necessary.