Ongoing Renewal of the School Curriculum –

Focusing, Deepening and Sustaining

Updating the Mathematics Education Key Learning Area Curriculum

(Primary 1 to Secondary 6)

Consultation Brief

Curriculum Development Council
November 2015

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Preamble

Ongoing Renewal of 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 is given to the development of personal attributes expected of our students across KLAs in the coming decade, and focuses such as Reading across the Curriculum (RaC), 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 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 Mathematics Education 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 the 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 Brief have a direct bearing on school-based curriculum development over the next decade and 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 feedbacks from stakeholders, in particular the school sector. Comments and suggestions on this consultation brief are welcome and should be sent by 4 Jan 2016 to:

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1. Why and how is the Mathematics curriculum updated?

The *Mathematics Education Key Learning Area Curriculum Guide (Primary 1 - Secondary 6)* (2016) is prepared by the Curriculum Development Council (CDC) Committee on Mathematics Education. It is an updated version of the *Mathematics Education Key Learning Area Curriculum Guide (Primary 1 - Secondary 3)* (2002) and has been extended to include the three-year senior secondary Mathematics Education.

In response to the changing needs of society, the rapid development of technology, views of stakeholders collected through various engagement activities and events (e.g. Key Learning Area surveys, New Academic Structure Review, curriculum development visits and focus group interviews), the results of international assessment (e.g. PISA and TIMSS) on the Hong Kong Mathematics education, as well as the direction for ongoing curriculum renewal (also known as Learning to Learn 2.0), the recommendations on Mathematics curriculum provided in the *Mathematics Education Key Learning Area Curriculum Guide (Primary 1 - Secondary 3)* (2002) are revisited.

Building on the strengths of Hong Kong students in mathematics as revealed from international studies, the Mathematics curriculum has been revisited for renewal to highlight key updated elements, especially STEM[1] education. Given that the elements of STEM education are already embedded in individual Key Learning Areas (KLAs) of Science Education, Technology Education and Mathematics Education of the local school curriculum, there is a need to strengthen the coherence and collaboration among KLAs. In this connection, the promotion of STEM education is a key emphasis to further enhance the quality and effectiveness of learning, hence enabling students to become more effective lifelong learners in the 21st century.

The updates of the Mathematics Education KLA Curriculum 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:

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

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.

[Please refer to Appendix 1 for the learning goals in primary education as listed in the *Basic Education Curriculum Guide – To Sustain, Deepen and Focus on Learning to Learn (Primary 1-6)* (2014)]

With no updates suggested for the curriculum aims and while the content of the Mathematics curriculum is going to be reviewed holistically, the following major areas for updates on curriculum management, pedagogies and assessment are put forth to accommodate students' learning needs arising from the changing contexts and education trends in the digital age, so as to provide suggestions for the development and implementation of the Mathematics Education KLA Curriculum at the primary and secondary levels for now and in the five to ten years to come.

- Enhancing the learning and teaching of the applications of mathematics and strengthening students' ability to integrate and apply knowledge and skills through **STEM education**
- Highlighting the importance of **e-learning** for enhancing learning and teaching effectiveness, facilitate self-directed learning and promote **Information Literacy (IL)**

- Strengthening the development of positive **values and attitudes** and **generic skills** in an integrative way through various Mathematics learning activities
- Highlighting **Language across the Curriculum (LaC)** in planning and implementing the school-based Mathematics curriculum. Reading in Mathematics would be promoted to develop students' understanding on the connection between Mathematics and the real life as well as other disciplines.
- Providing suggestions on **catering for learner diversity** in Mathematics learning, including addressing the needs of students with special educational needs (SEN) and gifted students in the mainstream Mathematics classroom
- Developing **assessment literacy** among teachers and students through extending assessment for learning to assessment as learning and developing students' self-directed learning skills

2. What are the Major Updates?

This part of the brief introduces the proposed major development and updates in the Mathematics Education Key Learning Area (KLA) to be elucidated in the *Mathematics Education Key Learning Area Curriculum Guide (Primary 1 - Secondary 6)* (2016) (hereafter referred to as "KLACG 2016" in this document)

2.1 Revisiting the curriculum aims

The Mathematics curriculum nurtures in students various abilities to think, to communicate and to handle mathematical objects. It helps develop important sense of numbers and space, as well as a positive attitude towards mathematics learning. These are also set out in the curriculum aims of Mathematics. The curriculum aims of the Mathematics Education KLA, which aligns with the overall learning goals of school education, will remain unchanged in the KLACG 2016. The curriculum aims are as follows.

Curriculum Aims of Mathematics
The overall curriculum aims of the Mathematics Education Key Learning Area are to develop in students: • the ability to think critically and creatively, to conceptualise, inquire and reason mathematically, and to use mathematics to formulate and solve problems in daily life as well as in mathematical contexts and other disciplines; • the ability to communicate with others, express their views clearly and logically in mathematical language; • the ability to manipulate numbers, symbols and other mathematical objects; • number sense, symbol sense, spatial sense, measurement sense and the capacity to appreciate structures and patterns; and • a positive attitude towards mathematics learning and an appreciation of the aesthetic nature and cultural aspect of mathematics.

2.2 Updating the curriculum framework

2.2.1 The updated curriculum framework

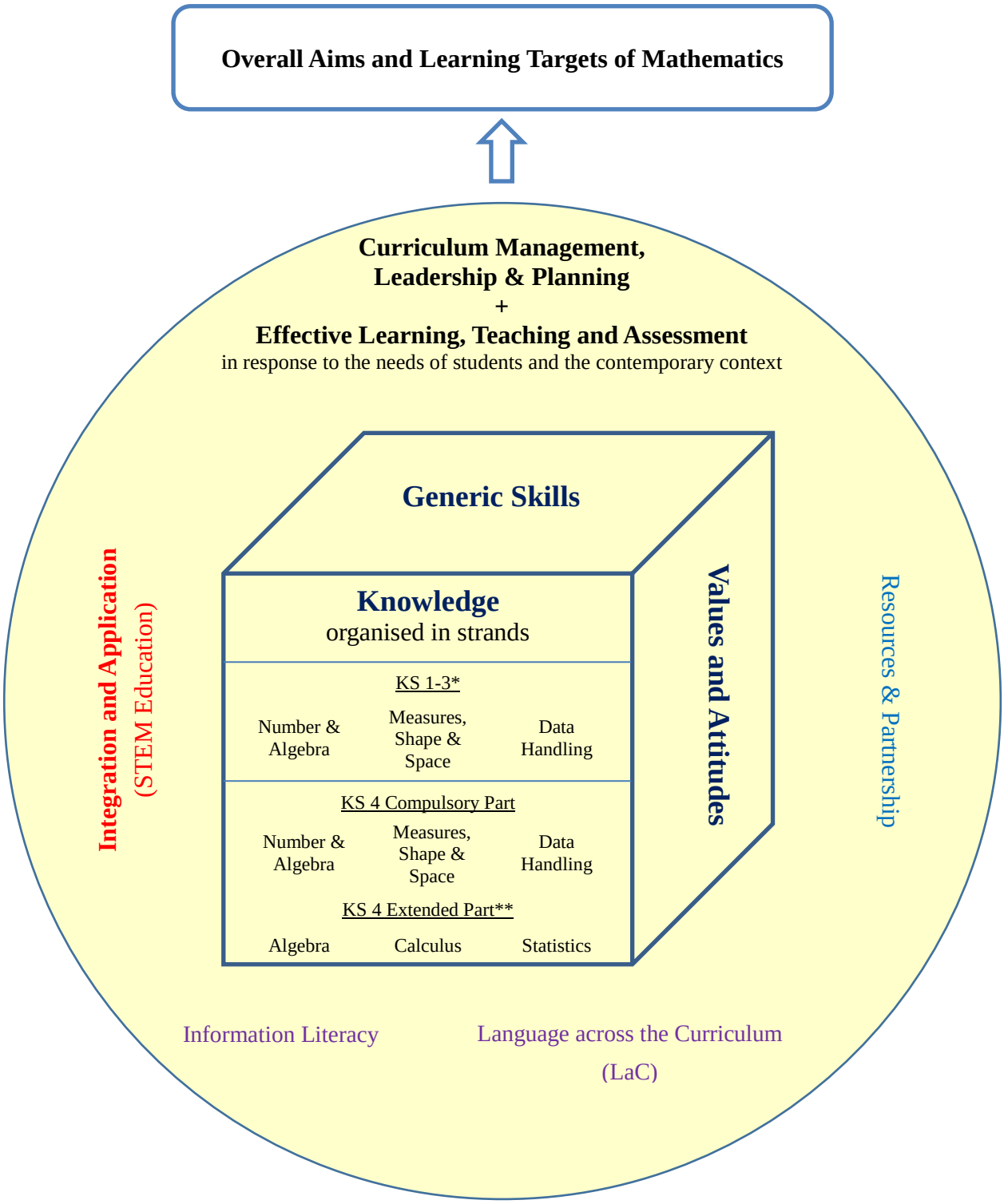
- The updated broad curriculum framework of the Mathematics Education KLA is presented in the diagram on the next page. The core part of the curriculum framework of the Mathematics Education KLA from P1 to S6 continues to be composed of Knowledge[2], Generic Skills, and Values and Attitudes[3]. The considerations for curriculum management, leadership and planning, as well as the effective learning and teaching of Mathematics involve not only the core part, but also the learning needs of students under the contemporary contexts, including the adoption of e-learning, and the development of students' language abilities and information literacy. The learning of Mathematics also connects with other KLAs/subject disciplines and the main focus is placed on integrating and applying knowledge and skills in STEM education. As before, the implementation of the curriculum needs the effective use of resources and the support from partners.

2.2.2 Holistic review of Mathematics curriculum

- Although there will not be proposed updates on curriculum content of the Mathematics curriculum at the levels of Strand, Learning Unit and Learning Objectives in KLACG 2016, updated suggestions on curriculum planning as well as learning and teaching will be given in the KLACG 2016 to enhance students' ability to integrate and apply knowledge and skills in STEM education and align with the considerations for curriculum planning of the ongoing curriculum renewal. Besides, a holistic review of Mathematics curriculum from P1 to S6 is intended to carry out to further incorporate the considerations for curriculum planning of the ongoing curriculum renewal into the curriculum content, to further improve the learning progression across key stages and to enhance the support to other disciplines, especially other STEM KLAs. The suggested plan of the review has been uploaded to the website of the Mathematics Education KLA (www.edb.gov.hk/cd/maths). Suggested issues to be addressed in the review, e.g. the content of Enrichment Topics of the primary and junior

[2] The framework and content of the knowledge part remains unchanged and according to the review recommendations of the New Academic Structure Medium-term Review announced in June 2015, the curriculum framework and content of senior secondary Mathematics is to be kept unchanged for the time being and continues to be reviewed with the finalised decision to be announced by July 2017.
[3] The updates of Generic Skills and Values and Attitudes are explain on p.10 and p.11 respectively.

Diagrammatic Representation of
the Mathematics Curriculum Framework



* In Key Stages 1 and 2, the strands are further divided into "Number", "Algebra", "Measures", "Shape and Space" and "Data Handling".

** Module 1 of the Extended Part consists of "Calculus" and "Statistics" and Module 2 consists of "Algebra" and "Calculus".

secondary Mathematics curricula, providing better support to the learning and teaching of other KLAs and subjects and strengthening the learning and teaching of Data Handling so as to support students' development of entrepreneurial spirit, are listed in Appendix 2.

2.2.3 Promoting STEM education

- In the local curriculum context, STEM education is promoted through Science Education, Technology Education and Mathematics Education, *within* and *across* 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 competiveness of Hong Kong.

- The objectives of promoting STEM education in schools are as follows:
  - 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 our nation

- 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 real-life problems and make inventions would help the development of positive values and attitudes among students as part of whole-person development.

These learning opportunities 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 on STEM education are elaborated in the Overview document on Promotion of STEM education – Unleashing Potential in Innovation

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

2.2.4.1 Refining 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 grouped in three clusters of related skills, namely "basic skills", "thinking skills" and "personal and social skills", for better integrative understanding and application:

Basic Skills	**Thinking Skills**	**Personal and Social Skills**
Communication Skills	Critical Thinking Skills	Self-management Skills
Mathematical Skills [a]	Creativity	Self-learning Skills [b]
IT Skills	Problem-solving Skills	Collaboration Skills

Remarks: [a] Numeracy Skills and [b] Study Skills were used respectively in *Learning to Learn: Life-long Learning and Whole-person Development* (2001)

- "Numeracy Skills" is renamed to "Mathematical Skills" to reflect a more comprehensive set of skills in various areas such as measurement, logical thinking, describing patterns and data handling for applications in different disciplines. "Study Skills" is replaced by "Self-learning Skills" for nurturing self-directed life-long learners.

- The Mathematics Education KLA provides meaningful contexts for the development of generic skills through appropriate learning and teaching activities and specific topics alongside KLA/subject specific skills. Schools should plan Mathematics KLA-related learning and teaching activities in a

holistic manner whereby the generic/cluster of skills would be suitably and effectively applied and developed. Teachers are encouraged to

- embed elements of generic skills in design of school-based learning goals, curriculum, learning activities as well as assessments;
- blend naturally the learning elements of generic skills with subject knowledge, values and attitudes;
- organise learning activities that require students to apply and reflect on their use of generic skills, such as projects, performance tasks and mini surveying activities; and
- create authentic learning environments that bridge students' learning of these generic skills with real world issues.

2.2.4.2 Promoting values education

- Values education/cultivation of positive values and attitudes is an integral part of the school curriculum through different components in KLAs/subjects, 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, have been 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 related to individual, family, society, the country and the world, 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 KLA/subjects, and design relevant learning experiences for students to nurture their positive values and attitudes. In Mathematics Education KLA, values education can be carried out through relevant topics and appropriate learning and teaching activities that help students apply and reflect on the priority or relevant values and attitudes (such as "taking

up challenges", "open-mindedness", and "cautiousness"), 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 judgement and decisions.

- In planning and implementing the school-based Mathematics curriculum, the Mathematics panel is suggested to include the development of positive values and attitudes by:
  - providing problems of reasonable level of difficulty to develop students' positive values such as "taking up challenges" and "persistence";
  - assigning open-ended questions to encourage students to be flexible, and to help students realise that there can be more than one way of looking at a problem;
  - assigning students to carry out short research projects about history of mathematics or the life stories of Chinese mathematicians to nurture students' humanistic quality; and
  - adopting inquiry and investigation approach in classroom learning and teaching to encourage construction of knowledge as well as the communication and collaboration between students. Positive values and attitudes, e.g. persistence, can be developed through responding to unexpected situations or situations that do not have an immediate solution.

2.2.4.3 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 Mathematics which provides 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. Students need to be equipped with new literacy skills to process and create multimodal texts in which messages are

conveyed through different forms. In mathematical reading, students need to handle multimodal reading materials made up of text, diagrams and mathematical symbols and the reading skills applied underpin information processing skills, such as identifying and analysing relationships between elements of multimodal texts.

- Therefore, Mathematics teachers are encouraged to collaboration with English and Chinese teachers to help students transfer literacy skills and strategies to the learning of Mathematics and to promote Language across the Curriculum (LaC) for more effective learning of Mathematics.

- Reading in Mathematics helps enhance students' interest in learning Mathematics and develop skills of reading to learn and literacy. The understanding on mathematical knowledge, daily-life applications and cultural aspects of mathematics that students acquire through reading provides students with a more comprehensive conception of mathematics and facilitate students' learning across the curriculum. Teachers are suggested to:

  - prepare quality Mathematics reading materials with suitable quantities in classrooms or in the school library and make use of the resources of public libraries;
  - review and categorise reading materials to fit students of diversified interest and abilities;
  - help students to connect their learning experiences within the content of Mathematics to the mathematics in daily life, cultural aspects of mathematics and other disciplines; and
  - design suitable post-reading activities to reinforce students' development of conceptions of the application of mathematics in different disciplines or the cultural aspects of mathematics.

(Please see Appendix 4 for Example 5 on organising and implementing Mathematics reading schemes.)

2.2.4.4 Strengthening Information Literacy (IL)

- Information Literacy is an ability and attitude that would lead to 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. Mathematics Education KLA has a role to play in developing students' IL. IL could be developed through the application of the generic skills in the context of handling information in different media in our information world. It involves various knowledge contexts and links with different KLAs, different subjects and STEM education. Infusion of IL in the Mathematics Education KLA would provide authentic contexts for students to apply the skills and better prepare students to live in the modern world as informed and responsible citizens. As an example, learning and teaching of topics on data handling and STEM-related project usually involve data collection, organisation, analysis, interpretation and reporting, which are essential skills related to IL.

2.3 Pedagogies (including e-learning)

2.3.1 Promoting e-learning

- Appropriate use of IT for e-learning in Mathematics is suggested to be one of the main focuses in the updating of the Mathematics Education KLA. e-Learning refers to an open and flexible learning mode involving the use of electronic media, including 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. In the context of Mathematics Education, e-learning is suggested to be promoted through:
    - greater use of IT to allow flexibility for learning inside and outside the classroom and to cater for learner diversity;
    - effective use of the IT environment (e.g. Wi-Fi infrastructure) to allow

flexible use of e-resources, IT tools and mobile devices;

- effective use of IT tools, such as using different mathematics application software (e.g. graphing tools, virtual 3-D manipulatives and dynamic geometry software) for multiple representations of abstract concepts, to enhance students' understanding of mathematics concepts;
- encouraging students to apply their IT skills for inquiry and investigation (e.g. using computation or graphing tools), presentation, critical thinking, information evaluation and knowledge management;
- applying IT to enhance students' motivation and engage students in interactive and collaborative learning activities; and
- effective use of e-learning resources to develop students' creativity, collaboration and problem-solving skills as well as self-learning skills (e.g. through the use of immediate feedback from online applets and assessment tools).

(Please see Appendix 4 for Example 4 on effective use of IT for enhancing the learning and teaching of Mathematics.)

2.3.2 Approaches for organising learning activities on STEM education

- In respond to the age of technology and innovation, STEM education is considered to be a major focus of updating of the Mathematics Education KLA. Mathematics teachers are suggested to help students develop knowledge, skills and positive values and attitudes associated with STEM education through:
  - organising learning activities with themes on application of mathematics, such as project learning, mathematical modeling or problem-based learning to provide contexts for students to integrate and apply their knowledge and skills in STEM related subjects;
  - creating a learning environment that draws students' attention to the application of Mathematics in Science and Technology as well as in daily life situations;
  - encouraging students to engage in mathematics reading on cross-discipline topics, e.g. mathematics and astronomy; and
  - designing learning activities to encourage students to work out innovative

solutions to problems or create new ideas or things to enhance their creative capacity.

- The Science, Technology and Mathematics Education KLAs and the primary General Studies have an important role in the promotion of STEM education at both the school and classroom level. Schools can strengthen students' ability to integrate and apply knowledge and skills, as well as develop their 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 being made on 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 natures, such as project learning, case-based/problem-based learning and mathematical modeling to provide meaningful contexts that are closely geared to the daily life for students to engage themselves in problem solving. The activities may include scientific investigations, "Design & Make" tasks, etc. that foster the ability to integrate and apply 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

- The above suggested at least two approaches that can be adopted by schools when arranging STEM learning activities for students:

Approach One	In this approach, the learning activity is based on a particular topic of a subject of a KLA (Science Education, Technology Education or Mathematics Education). Relevant learning elements are drawn from other KLAs to allow students to integrate and apply the knowledge and skills they have learned.

	For example, in a Mathematics topic about "Integral Indices", students study the index notation of numbers and numbers expressed in various bases. Related learning elements (e.g. representing and comparing sizes of cells using scientific notation and the use of binary numbers in computers) from other KLAs, could be incorporated as the learning activity moves on. At the end, students could be assessed for their understanding on the related learning elements and their ability to integrate and apply the knowledge and skills learned.
Approach Two	In this approach, a project learning activity is used to integrate all the related learning elements from Science Education, Technology Education and Mathematics Education KLAs. Students are given an authentic problem to start with. As the project progresses, students explore the issues, relevant learning elements from different KLAs are brought in by the students themselves, so that they could integrate the knowledge and skills they learned and apply them in a real life context.

A diagrammatic illustration of the two approaches is attached in Appendix 3.

- STEM education is also conducive to the development of students' entrepreneurial spirit. The learning activities associated with STEM education can help develop students' inquisitiveness to conceive new ideas and the ability to turn ideas into action, as well as nurturing the qualities of taking initiative and responsibilities, taking calculated risks and upholding perseverance. These qualities enable students to meet challenges and make the most of the opportunities ahead. Some of these qualities, such as taking calculated risks and making informed decisions through coat/benefit considerations, involves the application of mathematical knowledge (e.g. probability) and could be nurtured through learning activities in STEM education.

  (Please see Appendix 4 for Examples 1 and 2 (Approach One) and Example 3 (Approach Two) on learning activities for STEM education.)

2.3.3 Learning and teaching strategies

- With the focuses of STEM education and e-learning, some aspects of the learning and teaching of Mathematics are highlighted in the KLACG 2016 to

provide teachers with renewed strategies to achieve the aims of the Mathematics curriculum.

- It is important to nurture in students an all-round development with balance between their concept acquisition and application of computation algorithm, and between the applications of mathematics and abstract thinking.
- Project learning and problem-based tasks are suggested to provide students with opportunities to integrate knowledge across subjects, to apply IT skills and to develop generic skills as well as positive values and attitudes.
- Teachers are encouraged to use contemporary examples of application of mathematics to illustrate the use of mathematical knowledge in real life situations, such as the use of graphing skills in scientific investigation and performing error estimation of GPS tracking apps of mobile devices.
- Teachers are suggested to strengthen students' competency in applying mathematical software/application software (such as computer algebra system, dynamic geometry software, statistical tools and graphing tools) to preform problem-based learning or other learning activities.

2.3.4 Catering for learner diversity

- Learner diversity remains one of the major concerns in the Mathematics classroom at all levels and suggestions on strategies to cater for learner diversity are enriched in KLACG 2016. Diversity may manifest itself in many ways. Besides catering for students with different abilities, attention should also be paid to students' differences in learning styles. Teachers are encouraged, besides continue to take the role of a facilitator in Mathematics lessons, to understand students' learning characteristics in terms of learning style, cognitive development and pre-requisite knowledge.

- Teachers' attention is drawn to the effective use of learning and teaching resources, including textbook and e-resources, to cater for learner diversity.
  - Materials of textbooks are used selectively or with adaptation to cater for students' learning needs and interests. For the more able students, elementary examples and exercises may be skipped; and for the less able students, the more advanced examples, more-demanding questions and enrichment materials may be skipped.

- Hands-on learning activities, which are not replaceable by activities using IT, could be used for visualising concepts and computation process and for motivating students and provoking the understanding of abstract concepts.
- Teachers can choose suitable web-based learning materials to enhance students' motivation and to extend talented students' learning in their areas of interest, such as in the topic of mathematics and astronomy.
- Teachers can also select web-based interactive assessment tools with instant feedback to assist students' self-directed learning and to cater for students' different learning pace.

- Due consideration should also be given to support students with special education needs (SEN) and gifted students. To maximise the potentials of students talented in Mathematics, teachers are suggested to consider the following in the planning and implementation of the school-based Mathematics Education curriculum:
  - Allowing flexibility with the curriculum to address differences in the rate, depth and pace of learning
  - Providing enrichment activities which encourage creativity and original thinking
  - Encouraging students to pursue independent projects or study based on their interests and abilities
  - Guiding students to set individual goals and assume ownership of their learning

- To accommodate the needs of SEN students in the mainstream Mathematics classroom, teachers could consider the following in the planning and implementation of the school-based Mathematics Education curriculum:
  - Adapting the learning content
  - Adopting effective learning and teaching strategies
  - Using learning and teaching aids and materials
  - Reinforcing classroom management and instructions
  - Setting realistic assessment goals/objectives

2.4 Assessment

Assessment practices of "assessment for learning" have been developing in schools and a future direction for the development of assessment practices is to extend formative assessment from "assessment for learning" to "assessment as learning". These will all be highlighted in KLACG 2016.

2.4.1 Highlighting different modes of assessment for different purposes

- It is recommended for schools to build on their experience in implementing "assessment for learning" to further develop students' habits of mind and skills to monitor and evaluate their own learning. Meaningful learning takes place when students are empowered to take charge of their own learning.

- In extending "assessment for learning" to "assessment as learning", schools could allow greater involvement of students in the learning, teaching and assessment process. Students could be encouraged to set personalised learning goals, formulate plans to attain their learning goals, monitor their own learning performance, and evaluate their learning strategies. In this way, students gradually take ownership and responsibility for their own learning.

- Various tools are developed by the Education Bureau to support schools in implementing "assessment for learning" and "assessment as learning". These include the Basic Competency Assessment (BCA), the Learning Progression Framework (LPF) and Student Assessment Repository (STAR) for Mathematics.

    - The Basic Competency Assessment (BCA), which has been fully administered at primary three, primary six and secondary three since 2006, is an important assessment for providing schools with data for planning curriculum and designing teaching strategies to enhance the effectiveness of learning and teaching. In the KLACG 2016, schools are encouraged as before to make use of the BCA assessment date for reviewing the school-based curriculum and the effectiveness of the learning and teaching strategies.

    - The Learning Progression Framework (LPF) provides a common scale and language for teachers to describe students' performance and progress in Mathematics learning. Schools are encouraged to use the LPF as a tool for

planning the school-based Mathematics curriculum and assessment. A set of school-based performance descriptors can be developed with the use of the LPF to help students and parents understand students' performance in assessment tasks. Students can also be engaged in self-reflection and planning for improvement.

- The Student Assessment Repository (STAR) is an online assessment bank developed by the Education Bureau to enhance teachers' assessment literacy and improve students' learning by means of technology. STAR provides a range of assessment items that cover diversified question types and address the learning outcomes and pointers from the LPF for teachers to check students' progress or for students to conduct self-directed learning. STAR can provide online assessment data, such as reports on individual student's performance and the performance of a whole class, to help schools understand students' attainment and plan remediation and progression.

2.4.2 Assessment strategies for Mathematics Education KLA

- Schools should continue to introduce diversified modes of assessment and flexibly use different types of formative assessment. Other than collecting evidence of student learning through exercises, class discussion, oral presentation and performance task, assessment in the form of exploratory tasks, problem-based tasks and e-assessment can also be considered.

  - Exploratory tasks and problem-based tasks assess students' inquiry skills and problem solving skills on unfamiliar problems. When science or technology related topics or topics on the applications of mathematics in daily life are involved, the assessment tasks could also help develop students' STEM related skills. These tasks challenge students' integrative application of Mathematics concepts from different strands. Teachers could adjust the level of guidance and assistance provided to suit students of different abilities.

  - e-Assessment has been a powerful tool for teachers to cater for learner diversity, provide timely feedback and promote "assessment for learning". The design of some e-assessment platforms also encourages students to have more active involvement in monitoring their own learning to promote "assessment as learning". Teachers are encouraged to make flexible use of e-assessment platforms available at the HKEAA and HKEdCity websites.

2.4.3 Assessment for STEM-related learning activities

- Assessment in relation to STEM-related activities is implemented with a view to strengthening students' ability of integrating and applying the knowledge and skills from different STEM disciplines and fostering students' independent/collaborative learning capabilities.

- To assess STEM learning activities at school level, formative assessment could be adopted to collect evidence of student learning in both the knowledge and skill domains. During the course when the learning activities are organised, various assessment strategies, such as questioning, discussion, observation, self and peer assessments, and presentation, can be adopted. These assessment strategies allow teachers to provide timely feedback to students, and therefore guide them to monitor and reflect on their own learning. By the end of the learning activities, summative assessment, such as assessing students' final products or written reports, can be used to provide comprehensive information about what students have acquired.

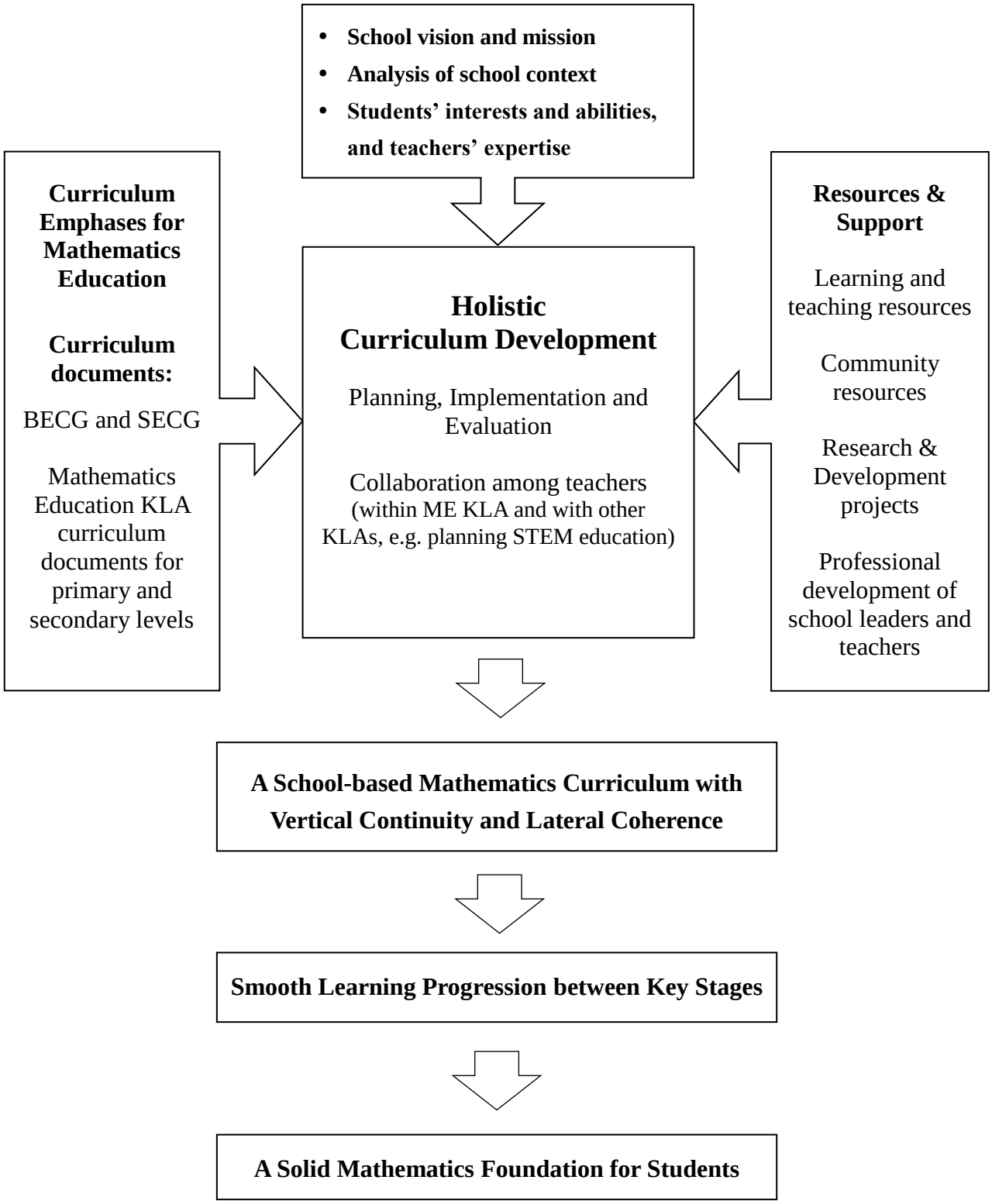
2.5 Curriculum management and planning of learning time

2.5.1 Holistic Curriculum Planning

- During school-based curriculum development for Mathematics, it is essential for schools to conduct holistic planning and strive for providing a balanced Mathematics curriculum that can meet the needs of students. The diagram on the next page shows the major factors to consider during holistic planning of the school-based Mathematics curriculum.

(Please refer to the diagram on the next page)

Holistic Curriculum Development in Mathematics Education KLA



2.5.2 Planning of learning time

- In KLACG 2016, the recommended time allocation for the primary and secondary Mathematics will not be suggested to change. Schools could refer to the respective curriculum document of each key stage for the recommended lesson time and related recommendations. Teachers are encouraged to use the time flexibly to help students attain the learning targets of the curricula, and to broaden students' learning experiences through various learning activities inside and outside classroom. As general recommendations, the proportion of time allocated for Mathematics at primary, junior secondary and senior secondary levels, as in the current curriculum documents, are as follows:
  - Primary level: 12 - 15% of total lesson time
  - Junior secondary level: 12 - 15% of total lesson time
  - Senior secondary level,
    - Compulsory Part only: 10 - 12.5% of total lesson time
    - Compulsory Part with a Module: 15% of total lesson time

- Schools are also encouraged to use the designated "flexible time" to conduct cross-curricular learning activities, e.g. values 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, the 10-15% time allocation is set aside for Other Learning Experiences (OLE). Should schools 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?

In order to facilitate schools to renew their school-based Mathematics curriculum to incorporate the major updates in the Mathematics Education KLA suggested in the *Mathematics Education Key Learning Area Curriculum Guide (Primary 1 - Secondary 6)* (2016), new, renewed or enriched supports in terms of the followings are provided.

3.1 Learning and teaching resources

Besides traditional learning and teaching resources, e.g. textbooks, models of 3-D figures and resources from school libraries, schools may also use the free learning and teaching resources developed and offered online by the EDB over the years. 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 teachers to access the many up-to-date digital resources that have been developed to support the learning and teaching of Mathematics. There are also free resources offered online in the website of Mathematics Education KLA (www.edb.gov.hk/cd/maths).

Resources available from other government departments, non-government organisations, tertiary institutions, professional bodies, etc. could be utilised to facilitate life-wide learning of Mathematics and enrich the learning experiences of students.

3.2 Partnerships with key players in the community

While the Mathematics Education Section of the Curriculum Development Institute, the School-based Curriculum Development Section (primary or secondary) of the Quality Assurance and School-based Support Division, and also the Regional Education Offices offer advices and support schools regularly on various aspects of learning and teaching, it is fairly common nowadays for schools to solicit support from tertiary institutions and professional organisations, through collaborative projects or professional development programmes (PDPs), to strengthen the professional development of their teachers.

To facilitate the promotion of STEM education, the EDB has been collaborating with various organisations, including the Hong Kong Association for Science and Mathematics Education, the Hong Kong Statistical Society, Hong Kong Science Park, Space Museum, Science Museum, and other relevant government departments such as the Leisure and Cultural Services Department, the Fisheries & Conservation Department, the Census and Statistics Department, etc. in organising various exhibitions, competitions and other student activities, as well as teacher seminars and workshops. The EDB will continue to strengthen the collaboration with the above organisations to enhance professional development of teachers and strengthen student learning.

3.3 Professional development of school leaders and teachers

The EDB will continue to provide professional development programmes (PDPs) for school leaders and teachers. To support the ongoing curriculum renewal and promptly respond to the feedback from schools on the training needs of teachers, the key focuses of the PDPs are as follows:

(i) Support for teachers to implement the senior secondary curriculum in areas of Understanding and Interpreting the Curriculum, Assessing Student Learning, Learning and Teaching Strategies, and Enriching Knowledge;

(ii) Support for school leaders, middle managers and teachers in curriculum management, leadership and planning;

(iii) Support for teachers on promoting STEM education and value education, enhance learning and teaching strategies, and cater for learner diversity; and

(iv) Support for teachers to promote information literacy and conduct e-learning.

There are specific supports on the major updates in the KLACG 2016 to facilitate schools to develop their school-based Mathematics curricula. They are summarised in the table below.

Major Updates	Supporting Strategies
STEM education	• Cross-KLA symposium will continue be organised for teachers to understand how to promote STEM education on holistic consideration. • New PDPs for curriculum leaders and teachers on school-based Mathematics curriculum planning as well as

	on learning and teaching of Mathematics for enhancing STEM education and cross-KLA collaboration will be provided. The EDB will also explore further collaborations with tertiary institutions and specialists in organising professional development programmes for teachers. • Schools with good practices will be identified for sharing with other schools in sharing sessions. • An integrative education fair relevant to Science, Technology and Mathematics Education KLAs will be organised to showcase a wide range of student achievements. Through sharing and learning from each other's work, a cross-disciplinary learning culture will be developed to promote students' interest and creativity in Science, Technology and Mathematics. This will pave the way for students' future studies and careers in related areas. • Learning and teaching resources will continue be produced and uploaded to the e-resources platform of learning and teaching for teachers' reference in the coming school years. The resources include STEM related cross-disciplinary learning activities and projects, schools' successful cases, life-wide learning activities and related reference materials. • The EDB will continue enhancing the collaboration among schools, tertiary institutions, professional bodies and related careers to promote their understanding and development of STEM education in related areas. It is hoped that through close partnership, further insights and good practices related to implementation of STEM education would be consolidated and shared among schools • Schools can acquire additional resources to conduct their school-based STEM education programmes and to build communities of practice to enhance knowledge exchange within and across schools through "Professional Development Schools Scheme" and "Quality Education Fund – QEF Thematic Network".

e-Learning and Information Literacy	• PDPs for primary and secondary teachers on e-learning will continue be provided and renewed to introduce up-to-date e-resources to teachers, equip teachers with the competency to design learning activities using common mathematics application software (apps) and give suggestions on effective and pedagogically sound application of e-resources. • Learning and teaching resources for e-learning in Mathematics will continue be provided through the EDB One-stop Portal for Learning and Teaching Resource (http://www.hkedcity.net/edbosp/). • Examples on the use of mathematics apps for effective learning and teaching will be provided in the KLACG 2016.
Other key emphases of the ongoing curriculum renewal	Generic skills • PDPs on generic skills will be renewed to introduce the new grouping of the nine generic skills and examples of learning and teaching activities in Mathematics for the integrative application of the skills. • The development of generic skills through learning and teaching activities in Mathematics will be illustrated through examples in the KLACG 2016. Values education • PDPs on promoting values education will be renewed to provide up-to-date examples on nurturing positive values and attitudes through both routine mathematics exercises as well as specific topics, such as discussion on personal financial management. • PDPs on history of mathematics will continue be organised to enhance teachers' competency in incorporating cultural elements of mathematics in Mathematics lessons, for provoking students' humanistic qualities. • The development of positive values and attitudes through learning and teaching activities in Mathematics will be illustrated through examples in the KLACG 2016.

	<u>Language across the Curriculum</u> • PDPs on reading to learn in Mathematics are renewed to promote reading in Mathematics and provide suggestions, good practices and solutions to schools on promoting Mathematics reading • The series of booklets, the "Mathematics Treasure Trove" series, are published by the Education Bureau to provide Mathematics teachers with references on learning and teaching of Mathematic, enrichment topics as well as the latest development of the application of Mathematics. The booklets can also serve as reading materials for students. Eighteen booklets have been published and more booklets will be published in the future. • The Mathematics Education Section will continue to organise the Mathematics Book Report Competition for Secondary Schools to enhance students' interest in Mathematics reading and to develop students' literacy. • Examples introducing the organising of Mathematics reading programme in schools will be provided in the KLACG 2016.

4. Frequently Asked Questions

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

A 1: Learning to Learn 2.0 is the 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. Ongoing engagement of stakeholders through multiple channels has been conducted in setting the direction for the ongoing curriculum renewal.

Q 2: **Is STEM a new strand in the Mathematics Curriculum?**

A 2: STEM is an acronym that refers collectively to the academic disciplines of Science, Technology, Engineering and Mathematics. It is not a new strand in the Mathematics Curriculum.

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 competiveness of Hong Kong.

STEM-related learning activities 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.

Q 3: **In promoting STEM education, what kinds of support will be provided by the EDB? Will any additional resources be provided to schools?**

A 3:

- **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 in July 2015, two events of another symposium cum consultation briefings were organised in early November to enhance teachers' understanding of STEM education. In the next three school years, a series of PDPs will 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 (e.g. through Professional Development Schools Scheme (PDS) of Education Development Fund (EDF), Quality Education Fund (QEF) Thematic Network). 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 related to Science, Technology and Mathematics Education 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 academic and practitioners who specialise 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.

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

Q 4: **Will schools be provided with IT resources or online platforms in support of the learning and teaching of Mathematics?**

A 4: One of the actions of the Fourth Strategy on IT Education is to enhance schools' IT infrastructure. With the enhanced e-environment, teachers can incorporate resources on the Internet and other e-resources to the Mathematics lessons more readily.

Teachers are encouraged to make effective use of IT and e-resources for engaging students in meaningful Mathematics learning activities, e.g. using dynamic geometric software package for presenting geometric properties of figures and using graphing tools to perform investigative activities on graphs of functions.

Opportunities for self-directed learning can also be provided through the adoption of IT. Teachers can select suitable interactive applets or videos on the internet for students' preparatory activities before the teaching of a topic. Students also can make use of the immediate feedback from online interactive applets to perform enquiry activities.

In the updated Mathematics Education KLA Curriculum Guide, useful e-resources will be suggested for teachers' reference. Examples of the use of IT for effective learning in Mathematics lessons are also provided.

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 given in the following table for reference

The Seven Learning Goals in BECG	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

Suggested Issues of Mathematics Curriculum to be addressed in the Holistic Review

A holistic review of Mathematics curriculum (P1 to S6) is intended to carry out to incorporate the key emphases of the ongoing curriculum renewal to the curriculum content, to further improve the learning progression across key stages and to enhance the support to other disciplines, especially other STEM KLAs. The followings are some selected issues of the primary and secondary Mathematics curricula that are suggested to be addressed in the coming holistic review

1. The content of Enrichment Topics of the primary and junior secondary Mathematics curricula
   - The Enrichment Topics in the current curricula are suggested to arouse students' interest and to extend students' exposure in mathematics.
   - Please refer to p.46-48 of the *Mathematics Curriculum Guide (P1 – P6)* (2000) and p.15-27 of the *Syllabuses for Secondary Schools – Mathematics (Secondary 1 – 5)* (1999) for Enrichment Topics in the primary and junior secondary Mathematics curriculum respectively.

2. The setting of Spare Periods in the primary and junior secondary Mathematics curricula
   - In the current primary and junior secondary Mathematics curricula, respectively 10%-16% and about 14% of the periods are suggested to be reserved as spare periods for teaching enrichment topics, arranging further exploration of certain learning units or adjusting the rate of learning and teaching.

3. Adjusting the teaching sequence of topics for better interface between Key Stages
   - In past Curriculum Development Visits and focus group meetings, reallocations of topics among Key Stages were suggested by teachers, e.g. whether "Area of Circle" should be introduced in KS2 or KS3.

4. Adjusting the teaching sequence and depth of treatment of topics to provide better support to the learning of other KLAs and subjects
   - In past Curriculum Development Visits and focus group meetings, there were views from teachers on adjusting the teaching sequence and depth of treatment of some topics in KS3, e.g. "Equations of Straight Lines" and

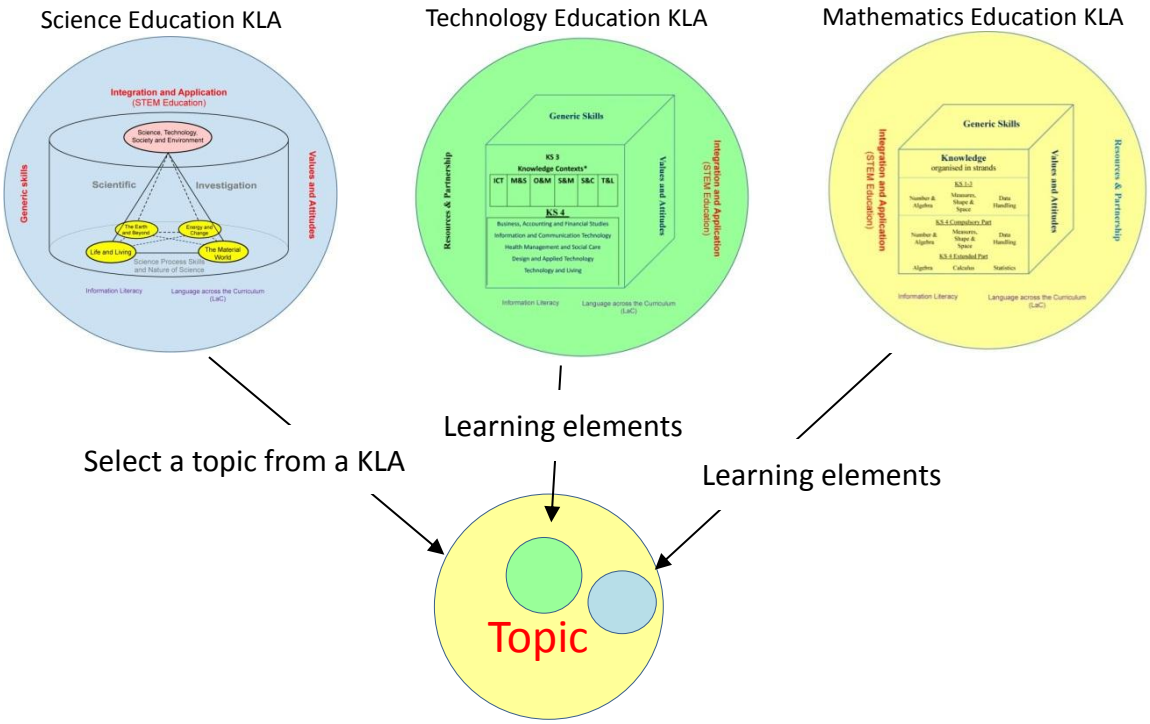
"Construction and Interpretation of Graphs" to provide better support to the learning of senior secondary science subjects.

5. The learning and teaching of Data Handling

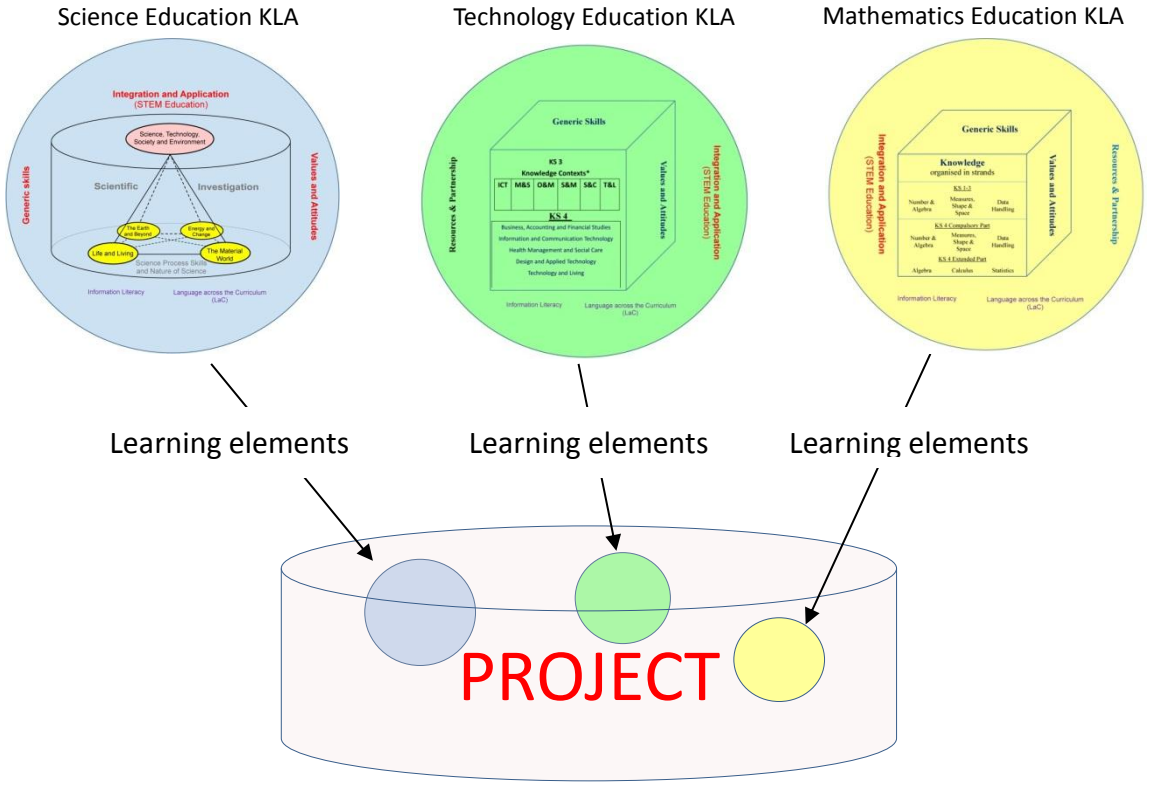
- The recent results of TIMSS suggested rooms of improvement in the learning and teaching of Data Handling. The strengthening of the learning and teaching of Data Handling could also support the development of entrepreneurial spirit.

Appendix 3

Two Approaches for Arranging STEM-related Learning and Teaching Activities



APPROACH ONE



APPROACH TWO

Appendix 4

Example 1
STEM Education

Rubber Band Powered Car

Key Stage	:	2
Learning Dimension/ Strand	:	Mathematics – Measures (Learning Unit: 6M3 Speed) General Studies - Science and Technology in Everyday Life (Learning Unit: Environment and Living)
Objectives	:	(i) To consolidate the concept of speed. (ii) To use "metres per second" (m/s) and "kilometres per hour" (km/h) as the unit of speed. (iii) To recognise efficient transfer of energy and the interaction between energy and materials. (iv) To design and build models by using different materials and to test selected functional characteristic of the model built with the chosen materials.
Prerequisite Knowledge	:	Understanding the relationship among speed, time and distance.
Teaching Resources	:	Worksheets, stopwatches, measuring tapes and calculators.
Related Links	:	Scientific Investigation Series - Potential Energy Car www.hkedcity.net/edb/teachingresources/project/?p=science&path=/car Scientific Toy DIY- Rubber Band Powered Car sites.google.com/site/sciencemagician/ke-xuediy/xiang-pi-jin-dong-li-che-guang-die-che

Description of the Activity:

Activity 1

To consolidate pupils' concept of speed by teacher's questions raised.

Questions for discussion:

1. If A and B run 100 metres in 20 seconds and 30 seconds on average respectively. Who runs faster?
2. If C and D run 50 metres and 60 metres in 10 seconds on average respectively. Who runs faster?
3. What is the relationship between time and speed if they run the same distance?

   What is the relationship between distance and speed if they run at the same time?
4. What information must be obtained to determine their running speed if they do not start in the same place?

Notes for Teachers:

Pupils are divided into groups and provided the related links. They could prepare and make the rubber band powered car prior to the lesson.



Activity 2

1. The teacher read out Part 1 of Worksheet as an introduction. Pupils are grouped in pairs. Pupils discuss the ways to compare 2 persons' speeds when the distances they run and the time they spend are different. The teacher guides pupils to find the formula which is used to calculate the average speed.
2. Each group is given the Worksheet. Pupils complete Part 1 of Worksheet and present the results.
3. Pupils collect the data and complete Part 2 of Worksheet by using their rubber band powered cars.

Questions for discussion:

1. If we obtain the distance an object moves and the time it spends to move, how can we calculate the average distance it moves in 1 second?

2. How can we calculate the average time it spends to move 1 metre?

3. Which method do you like to use to compare their speeds? Why?

4. The distances the 2 persons run and the time they spend are different. How can you compare their speeds?

Notes for Teachers:

1. Activities aim at measuring the speed of their rubber band powered cars, not the speed racing. There is no need to arrange each car starting at the same place and same time.
2. The teacher can remind pupils to refer to the design and materials used by each other groups in order to improve their own rubber band powered car.

Activity 3

To discuss with pupils the energy conversion and how to improve the structure of the car.

Questions for discussion:

1. When a pupil is scrolling the rubber band, what kind of energy is stored?

2. When pupils put their cars on the ground, what kind of energy will be converted from the energy stored in the rubber band? What is the relationship between this kind of energy and the speed of their cars?

3. How to increase the speed, stability and durability of the rubber band powered car?

Notes for Teachers:

1. To save time, the teacher may allow pupils to complete Part 2 of Worksheet using a calculator to perform the calculation.

2. The teacher can remind pupils how to use the stopwatch and measuring tape to record the test results.

Integration and Application:

Science Education:	Conversion of energy
Technology Education:	Model design and choosing appropriate materials
Mathematics Education:	Concept of speed and measurement of speed

Worksheet

1. The running records of Pupil A and Pupil B are as follows:

	Distance	**Time**
A	100 m	20 s
B	150 m	25 s

How to Compare the speed of A and B?

method 1	method 2
A has run _____ m in 1 second. B has run _____ m in 1 second. Pupil _____ runs faster, because the distance he/she runs is _____ in 1 second.	A has spent _____ s to run 1 m. B has spent _____ s to run 1 m. Pupil _____ runs faster, because he spends _____ time to run 1 m.
Which method do you like to use to compare their speeds? Why?	

2. Complete the following table and calculate the speed of rubber band powered car.

Distance (m)	**Time (s)**	**Speed (m/s)**

Remark: The speed calculated can be rounded off to 1 decimal place.

Example 2
STEM Education

Measurement by GPS Tracking Apps and Investigating the Errors of Measurement

Key Stage: 3

Mathematics Education

Learning Dimension: Measures, Shape and Space
(Learning Unit: Estimation in Measurement)

Technology Education

Knowledge contexts: Information and Communication Technology
(Module: Computer Systems)

Objectives:
(i) To develop estimation strategies in measurement
(ii) To handle and reduce errors in measurement
(iii) To understand and apply ICT as a prime tool for learning and in our daily life

Prerequisite Knowledge:
(i) Calculate different types of errors
(ii) Use rate and ratio to solve real-life problems in measurement

Teaching Resources: Scaled floor plans of the school playground, trundle wheels, and tablet computers with GPS tracking apps installed

Description of the Activity:

1. The teacher introduces the activity to students and revises the concept of rate and ratio.
2. The teacher gives each student a scaled floor plan of the school playground.
3. Students, working in groups, estimate the dimensions of the playground. Each group will be invited to present their strategies in their estimation.
4. Students measure the dimensions of the playground on the floor plan and calculate the actual dimensions of the playground by consideration the scale ratio of the floor plan.
5. Students discuss how to verify the answer found in (4).
6. Students use trundle wheels and GPS tracking apps to measure the dimensions of the playground.
7. Students compare the results obtained in (4) and (6).
8. Students calculate the percentage errors of the calculation in (4) and the measurement by GPS tracking apps, the measurements by trundle wheels can be taken as the reference value for calculating the error of the measurement by GPS tracking apps.
9. Students discuss which method of measurement is more reliable and how to reduce the errors in measurement.

Notes for Teachers:

1. It is desirable for students to work in small groups.
2. The teacher should allow ample opportunities for students to discuss and draw conclusion by themselves instead of giving them straightforward hints.
3. The teacher should prepare prior information about the dimensions of the school playground.
4. The teacher should install the GPS tracking apps in the tablets before the lessons.
5. GPS function is widely used nowadays. Teachers could encourage students to find out the principle and usage of GPS from the Internet.
6. Error calculation is frequently involved in the learning of Science and Technology subjects. The use of new measuring equipment, the GPS tracking app,

challenged students understanding on error and the way to calculate it. Students need to apply the mathematics knowledge on finding relative error to study the new technology for measurement.

This exemplar mainly involves the following generic skills:

1. Critical Thinking Skills
   - Understand the restrictions of real measurement
   - Evaluate the ways of finding the actual dimensions of the school playground
   - Draw logical conclusions based on adequate data and evidence, for example, by comparing different methods and related errors in measuring to conclude the most appropriate method for taking measurements

2. Communication Skills
   - Understand, analyse and respond to teacher's spoken instructions and instructions on worksheets
   - Use appropriate language and mathematical expressions to present the methods and results of calculations
   - Discuss and work with others to accomplish tasks, for example, determining the most appropriate way to take the measurement through discussion

3. Problem-solving Skills
   - Compare the results of different measurement methods and justify the method selected

4. Information Technology Skills
   - Use the GPS tracking apps in the tablet to carry out the exploratory activities

Example 3
STEM Education

Developing Integrative Learning Capabilities through Project Learning

Key Stage: 3

Curriculum: Cross-KLA

Emphasis: STEM education / The ability to integrate and apply knowledge and skills

Project Topic: Design a healthy diet menu for a school lunch box supplier

KLA	Learning Elements
Science Education	• Common food substance • Function of food substance • Food pyramids • Balanced diet • Healthy lifestyles
Technology Education	• Food groups, dietary goals and eating habits • Meal planning • Principles and skills, hygienic and safe practices in food preparation • Food product development – using a design cycle to create and develop food products to meet the design specifications of a task e.g. address the health concerns of teenagers and sensory requirements of the products • Health lifestyle / sedentary lifestyle / unhealthy lifestyle
Mathematics Education	• Estimation and measurement • Collect and organise data • Construction and interpretation of statistical graphs • Measures of central tendency

- In this activity, teacher adopts a cross-disciplinary approach to integrate the learning of Science KLA, Technology KLA and Mathematics KLA. The project itself is arranged as an independent activity. Learning elements from different KLAs would be drawn in by the students themselves or by the teachers during the course of the project learning activity.

- In the beginning, the teacher chooses an authentic problem which most students would be concerned. Quite often, there are students complaining about the taste,

quality and quantity of the lunch boxes provided by the school canteen. On the other hand, the nutritional values of the lunch boxes are also an issue related to the health of teenagers. Therefore, teachers can ask students to conduct a project work to design a healthy diet menu for the lunch box supplier, to meet with the needs of healthy and quality food in school.

- Starting from the essential question, plenty of learning opportunities can be provided for the students to construct, integrate and apply knowledge and skills from different KLA. 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 mathematical skills to calculate and analyse the nutritional values of different food. Students could conduct a survey to collect food preference of their fellow students, and prepare food for tasting. After proper analysis, student can submit the healthy diet menu to the school lunch box provider for reference.
- During the progress of the project, teachers can provide proper guidance and provide feedback, resources and assistance to their students when needed.

Example 4
Effective Use of IT

Slopes of Perpendicular Lines

Key Stage: 3

Learning Dimension: Measures, Shape and Space

Learning Objective: To enhance the understanding of relation between slopes of perpendicular lines

Learning Unit: Coordinate Geometry of Straight Lines

Material Required: Dynamic Geometry apps for tablets (e.g. GeoGebra)
A video clip on the topic "Rotation of Points about the Origin"
iOS or Android based tablets

Prerequisite Knowledge:
(1) The changes to the coordinates of a point after a rotation about the origin through multiples of 90 in the rectangular coordinate plane
(2) Finding the slope of a straight line
(3) The property of slopes of parallel lines

Pre-lesson Preparatory Activity:

1. The teacher asks students to watch the video clip "Rotation of Points about the Origin" at home and answer the following question before the lesson.

   "What are the coordinates of a point $P(s, t)$ after a rotation of 90° about the origin?"

Activities for the lesson:

- Activities 1 and 2 below are designed to guide students to discover and understand the relation between slopes of perpendicular lines.

- Before the activities, the teacher first gives a brief review on concepts introduced in the pre-lesson activity to see whether students have any questions about them.
- The teacher may recall what students had learnt in S1 about rotation of points in the rectangular coordinate plane.

Activity 1

1. Students are asked to use the freeware GeoGebra to
   (a) construct a straight line L, which passes through the origin O, and the point $P(6, 5)$,
   (b) rotate the straight line L through 90° about the origin to form a new straight line L_1 ,
   (c) consider the point Q, which is the image of P after a rotation of 90° about the origin, mark the point Q on L_1 by rotating P.
2. Students are then asked to
   (a) find the slopes of L and L_1 by considering the coordinates of P and Q respectively,
   (b) observe the relationship between the slopes of L and L_1 and draw a conclusion.
3. repeat steps (1) and (2) above a few times with different coordinates of P and verify the conclusion drawn in step 2(b).
4. During the construction process, the teacher may prompt students with the following questions:
   (a) [in step 1(b)] What is the relationship between L and L_1?
   (b) [in step 1(c)] What have you got for the coordinates of Q ?
   (c) [in step 2(a)] How do the results relate to the coordinates of P ?
   (d) [in steps 2(b) and 3] What conclusion can you draw? Can you think of another way to present your conclusion?
5. Let students have sufficient time for discussion and exploration before drawing

any conclusion.

Activity 2

1. Teacher may then repeat Activity 1, but this time the line L passes through the points $P(5, 0)$ and $Q(1, 6)$ and ask students to rotate the line about point $R(3, 3)$ and consider the slopes of the two lines.
2. Students are required to perform group discussion on whether the conclusion in Activity 1 step 3 still holds for lines not intersecting at the origin. Students are required to provide a logical explanation on their conclusion.

Notes for Teachers:

1. It is desirable for students to work in small groups.
2. The teacher should allow ample opportunities for students to discuss and draw conclusions by themselves instead of giving them straightforward hints.

This exemplar mainly involves the following generic skills:

1. Problem-solving Skills
   - Identify the main focus of the problem by building connection between the prerequisite knowledge of point rotation with the perpendicularity of straight lines.

2. Information Technology Skills
   - Use dynamic geometry apps and tablet computers to facilitate learning

3. Self-learning skills
   - Check the mastery of prerequisite knowledge for the learning of the new topic through the pre-lesson preparatory activity

Example 5
Mathematics Reading Scheme

Reading to learn is one of the four key tasks in the curriculum reform aiming to enhance students' skills in learning to learn and self-directed learning. Through adopting Reading across the Curriculum, reading activities can promote cross-discipline learning. This exemplar serves to suggest reading programme with activities that can be used:

(i) to develop students' interest and habit in reading in Mathematics and enhance their literacy;

(ii) to develop students' generic skills (such as communication skills and self-learning skills);

(iii) to provide opportunities for students' to link mathematical knowledge with content of other subjects (Learning across the Curriculum); and

(iv) to broaden students' understanding on the applications of mathematics in real life and the cultural aspect of mathematics.

<u>Planning of Reading Programme/Activities</u>

Below are some suggestions to help schools to set up a Mathematics reading programme:

- Schools could set up long term and short term objectives of the reading programme and implement the reading programme by stages
- Schools could formulate their reading programme for promoting reading in Mathematics with reference to
  - schools' major concerns,
  - students' reading competency,
  - students' interest and ability in Mathematics,
  - teachers' experiences in promoting reading, and
  - reading resources available for students.
- Schools could build up the collaboration between the Mathematics panel, other subject panels and the school library for organising reading programme for students
- Teachers could review and categorise Mathematics reading materials which suit the interest and ability of the targeted students and plan in advance to increase the quantities of good Mathematics reading materials in classrooms or in the school library. Teachers are encouraged to make good use of resources of public libraries.

- Teachers could design suitable post-reading activities to reinforce students' learning and help students discover the mathematics concepts, application of mathematics in different disciplines or the cultural aspects of mathematics in the reading materials.
- Schools could choose appropriate methods of evaluation with suitable success criteria, and evaluate the effectiveness of the implementation plan regularly.

Schools examples:

School A (Primary)

Background: Reading to learn is a major concern of the school in the current school development cycle. Students of the school are keen on reading but they have very little experience in reading mathematics books. Parents are supportive to school's policies and the reading scheme. The school has provided more mathematics books for lower primary students in the school library.

Implementation plan of the Reading Scheme

Target: Primary 2 Students

Objectives:

1. To create a positive atmosphere of learning Mathematics through reading
2. To arouse students' interest and develop reading habits in reading Mathematics books or passages
3. To enhance students' communication skills through sharing activities

Activities and Strategies:

- Introduction of the Reading Scheme:
  To brief parents and targeted students the objectives, activities and details of the scheme in a morning assembly in September.

- Reading with parents:
  Teachers deliver one mathematics book or a reading passage each time in a reading bag for students to read at home with their parents and fill-in the record book. Four times in each term.

- School-wide Reading Programme:
  Cooperate with the School-wide Reading Programme of the school library to

encourage students to borrow mathematics books in the library. Students have to record their reading in a record book. They receive awards after the completion of the Programme and can earn an extra gift for every three mathematics books read.

- Reading with buddies
  Arrange students of P.5 and P.6 to be Mathematics Ambassadors to read books with P.2 students in the morning reading period once a week.

- Good books or passages election
  Students share one of the books or passages read and elect the ten most popular books or passages after the sharing session in each term.

School B (Secondary)

Background: The school has carried out a reading pilot scheme in S1 last year to arouse students' interest and to help students develop reading habits in reading mathematics books. Teachers participated in the pilot scheme share students achievement and the effectiveness of the pilot scheme within schools' Mathematics Department. Built on experience and good practices, they are keen to extend the reading scheme to all junior forms.

Implementation plan of the Reading Scheme

Target: Junior secondary students

Objectives:

1. To enhance students' thinking skills, problem solving skills and creativity through reading in mathematics
2. To broaden students' knowledge and exposure in mathematics
3. To nurture students' understanding of the cultural aspects of mathematics
4. To help students to link the learning of Mathematics with other subjects, e.g. language subjects and History.

Activities and Strategies:

- Mathematics Reading Group:
  Students work in groups of four to study on a theme set by the teachers. They are required to search and read relevant books or information from the internet.

The themes of S1, S2 and S3 are “Stories of Mathematicians”, “Mathematics games and puzzles” and “Mathematics in daily life” respectively.

- Books Recommendation:
  Teachers regularly share and recommend relevant books or reading materials from the internet for students to read in order to help them carry out their study.

- Reading Worksheet:
  The teachers design different worksheets on each theme for students to complete. For example, S1 students are required to select a mathematician, read his life and contributions and set a question on what they have found out about the mathematician. For S2 students, they have to read books about mathematical games and puzzles, and then post challenging problems for their classmates.

- Sharing Sessions:
  After the group work, students present and share their reading experiences and achievements in the class. They share the questions posted in the worksheet for class discussion.

- Publication of Students’ Work:
  Teachers compile a collection of students’ work into a book to showcase students’ achievement in reading.