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Nurturing of local talent

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Hong Kong is lagging behind many developed economies in nourishing local talent. Cultivating STEM literacy in primary and secondary schools, as well as building a local talent base sourced from university graduates, should help boost the supply of local talent. The need for continuing education after formal schooling is also important for talent to keep abreast of new knowledge and skills and avoid becoming obsolete.

While the Government has invested a lot of resources in STEM education, the efforts to promote STEM are planned by schools themselves under the "school-oriented" approach. In Singapore, the Ministry of Education has partnered STEM Inc in developing and implementing STEM. STEM Inc works with teachers to co-develop STEM curriculum and co-teach STEM lessons.

At universities, STEM programmes fail to attract students with the best academic results and places on research postgraduate programmes have been filled largely by Mainland students. Hong Kong's talent admission schemes have met with limited success in attracting Mainland students to work and stay in the territory after graduation.

The Government set up the Continuing Education Fund as early as in June 2002, but the continuing education participation rates have been relatively low over the years. In contrast, Singapore has been identified as a successful example of incentivizing firms and individuals to invest in continuing education through its SkillsFuture movement. Singaporeans are provided with SkillsFuture Credit to pay for approved courses, and the Singaporean government will provide periodic top-ups. Generous government subsidies are also provided for self-sponsoring and employer-sponsoring courses, and employers are entitled to Absentee Payroll funding as well.

The subject of nurturing of local talent falls within the policy area of the Panel on Manpower.

1. Background

1.1 Talent development, attraction and retention are among the most vital elements in the discussion of economic development today. Successful economies are those that possess the skilled talent necessary for competing in an increasingly knowledge-based and innovation-led global world. While many emerging and developed economies are adopting preferential policies to attract foreign talent from around the world, they are also committed to nurturing local expertise for building a pool of highly skilled talent.

1.2 According to the Government[1], human capital is the most important driving force for the sustainable development of Hong Kong and nurturing more local talent is the key to success. Yet, Hong Kong is lagging behind in nourishing local talent. It was ranked 20th in terms of investment in and development of home-grown talent in International Institute for Management Development's 2019 World Talent Ranking[2], a report which assessed 63 economies in their capability to attract and foster talent.

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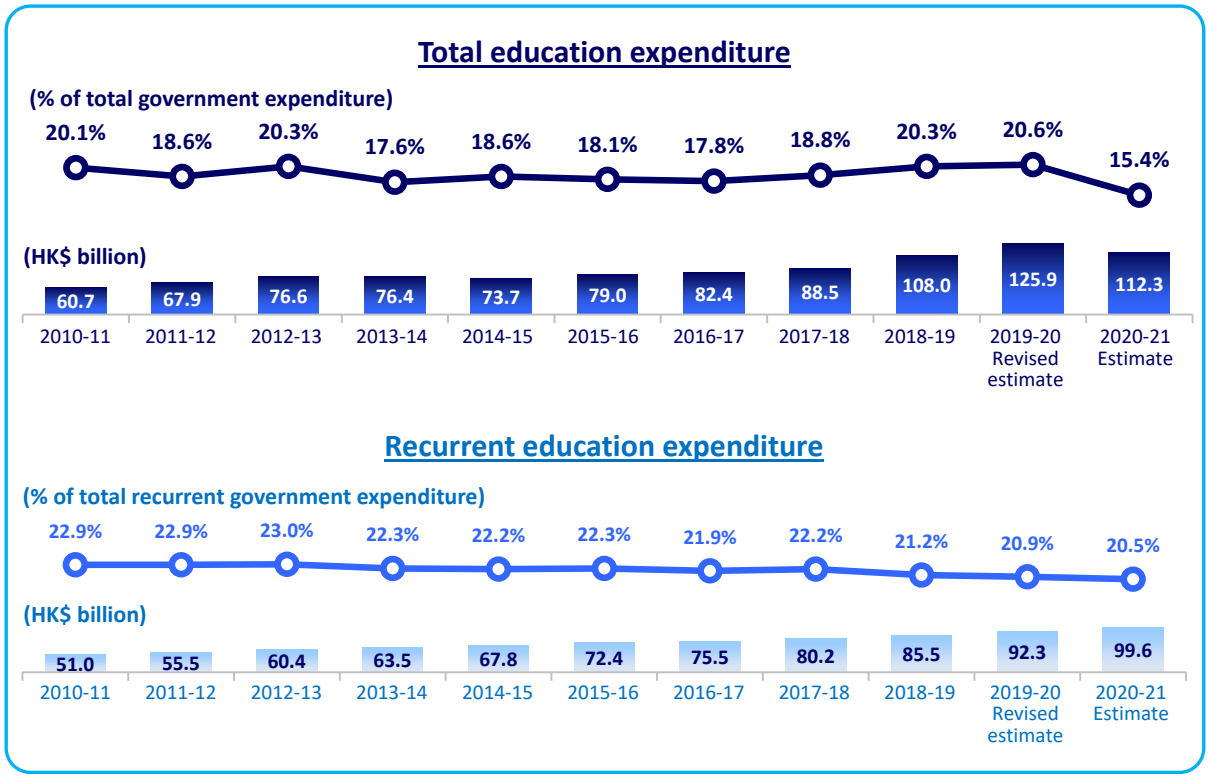
1 See Chief Secretary for Administration (2018).

2 International Institute for Management Development is a business school based in Lausanne (Switzerland) and Singapore.

1.3 Nurturing local talent starts with education. **Internationally**, Hong Kong was only ranked 53rd in total public expenditure on education in IMD's 2019 report. On education resources for secondary students, Hong Kong was ranked 30th in government expenditure on education per student and finished 27th in the pupil-teacher ratio. Likewise, the 2019 Global Innovation Index[3] ranked Hong Kong 48th in education among the 129 economies assessed.

1.4 **Domestically**, the share of total expenditure on education in total government expenditure has declined over the past years from 20.1% in 2010-2011 to 15.4% in 2020-2021 (**Figure 1**). As a proportion of total recurrent government expenditure, recurrent education expenditure also exhibited a declining trend from 22.9% to 20.5% over the same period. Recurrent education expenditure, which reflects the Government's long-term commitment to education, has the year-on-year growth in real terms at 7.2% in 2020-2021, the third lowest among the 10 policy areas.

Figure 1 – Expenditure on education, 2010-2011 to 2020-2021

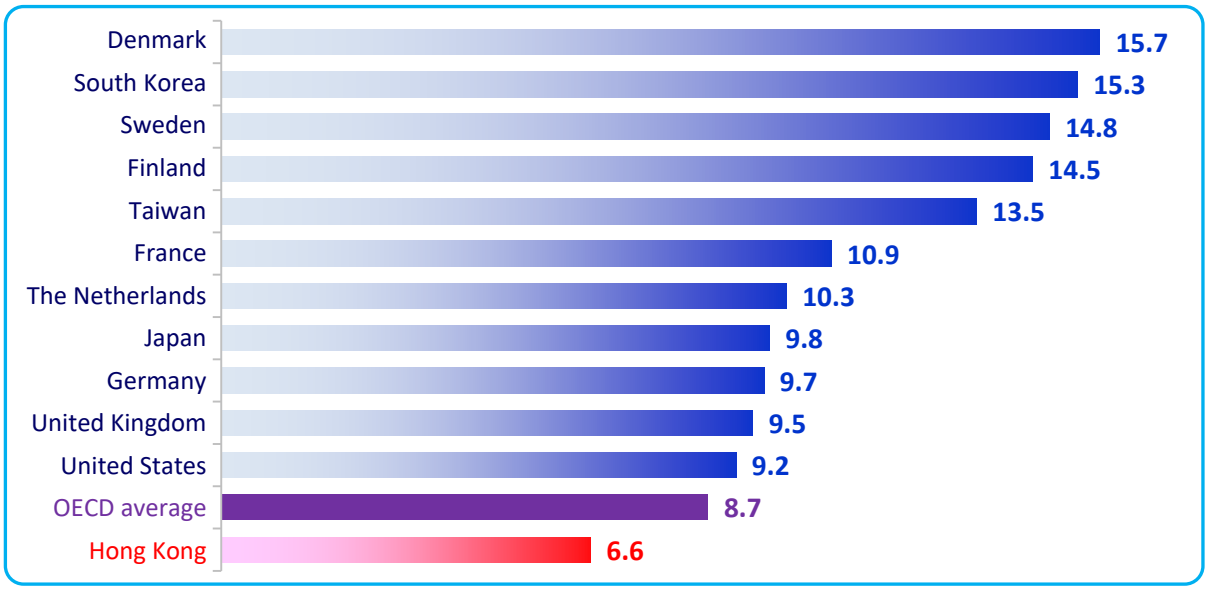


Data sources: Budget Speech (various years) and Financial Services and the Treasury Bureau.

[3] The Global Innovation Index ranks the innovation performance of 129 countries and economies around the world, based on 80 indicators including education, political environment, infrastructure and business sophistication. It is published annually by Cornell University, INSEAD and the World Intellectual Property Organization.

1.5 In addition to the level of investment in education, another concern is whether Hong Kong itself has sufficient talent for the knowledge- and innovation-driven New Economy. Hong Kong currently has a relatively small pool of research talent. In 2018, it had 6.6 researchers per thousand employment[4], a ratio lower than that of some Asian developed economies and Organisation for Economic Co-operation and Development ("OECD") countries (**Figure 2**).

Figure 2 – Number of researchers per thousand employment, 2018 or latest year available



Data sources: Census and Statistics Department (2019a) and Organisation for Economic Development and Co-operation (2020b).

1.6 As a small city economy, Hong Kong is unlikely to be self-sufficient in the supply of talent from its population of 7.5 million. There is a need to bring in talented people from outside to meet the manpower needs of the New Economy. Nevertheless, Hong Kong still needs to cultivate more home-grown talent to offset any shortfall in attracting and retaining foreign talent amid intensifying global competition for talent.

1.7 Cultivating STEM literacy in primary and secondary schools[5], as well as attracting more elite students pursuing STEM programmes at universities,

[4] The number of researchers is expressed in Full-time Equivalent, which is defined as the actual number of employee man-months deployed to research and development ("R&D") activities during the reference year divided by 12.

[5] According to the National Science and Technology Council (2018), "[b]asic STEM concepts are best learned at an early age – in elementary and secondary school – because they are the essential prerequisites to career technical training, to advanced college-level and graduate study, and to increasing one's technical skills in the workplace."

should help secure supply of local talent for the New Economy. Building a local talent pool from research postgraduate ("RPg") students also contributes.[6] However, STEM education has been identified as a weak link in the development of innovation and technology in Hong Kong[7], whereas the STEM programmes at University Grants Committee ("UGC") funded universities fail to attract students with the best academic results. Furthermore, places on RPg programmes have been filled largely by non-local students, who might not stay in Hong Kong after graduation.

1.8 While nurturing local talent starts with education at schools and universities, one's learning can and does occur beyond the formal structure of an educational institution. The rapidity of technological advance makes it no longer feasible to equip learners through traditional schooling with all the skills they need to prosper through their lifetime career development. Indeed, the skills that are considered desirable for tomorrow's talent to possess are always changing. The need for continuing education has never been more important for today's talent to adapt to the accelerating changes to jobs brought about by technological advance. Yet, the continuing education participation rates in Hong Kong have been relatively low in recent years.

1.9 Against the above, this Research Brief examines (a) the development of STEM education in Hong Kong, as well as the relevant experience in selected economies where STEM education is promoted through legislation, dedicated authorities, a national strategy or other specific measures; (b) local students' enthusiasm towards pursuing a STEM-related undergraduate degree in Hong Kong; (c) students admitted to RPg programmes at UGC-funded universities; and (d) continuing education in Hong Kong.

2. Development of STEM education in Hong Kong

2.1 The STEM acronym was introduced in the United States ("US") in 2001, referring to a curriculum based on the idea of educating students in four specific disciplines – science, technology, engineering and mathematics. Over the past two decades or so, STEM has been evolving from the concept of clustering four related disciplines towards a more integrated and interdisciplinary approach to learning and skill development.

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[6] According to Hong Kong Foundation (2019), postgraduate students are potential research professionals who can form a strong talent base for sustaining Hong Kong's R&D in the long run.

[7] According to a survey conducted by Google in 2019, 64% of corporations surveyed consider staff with a STEM education are the hardest to find, while 51% of small and medium-sized businesses enumerated deem it to be the second most difficult discipline to recruit.

2.2 STEM curriculum incorporates the "four C's" of the 21st century skills: critical thinking, creativity, collaboration and communication[8]. Engaging students in STEM disciplines helps develop a pool of potential talent for the society, as jobs today are proactively seeking candidates who possess skills revolving around STEM. In the New Economy, candidates are expected to manage not only industry expertise and technical skills, but also soft skills such as sociability, flexibility, creativity and co-operation.

2.3 In Hong Kong, the promotion of STEM education was first proposed in the 2015 Policy Address and further supported in the 2016 Policy Address. In late 2016, the Education Bureau ("EDB") released the report "Promotion of STEM Education – Unleashing Potential in Innovation" setting out the direction for the promotion of STEM education in primary and secondary schools. This includes the review of the curricula of Science, Technology, Mathematics Education Key Learning Area ("KLAs")[9], as well as the adoption of "school-oriented" policy for the implementation of STEM education.[10]

Design of STEM education

2.4 While the Government has invested heavily in STEM education[11], Hong Kong is still falling behind its peers in STEM development. Under the "school-oriented" policy, EDB allows schools the flexibility to adopt different emphasis/plans and incorporate different learning elements for the implementation of STEM education. Yet, the approach has been criticized for being too "loose". In 2018, local media reviewed 509 primary schools

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8 Over the course of their STEM education, students need to develop their critical thinking to formulate innovative solutions to solve real-world problems. They should also be able to work together and communicate their solutions with others.

9 STEM is not a separate and new subject in Hong Kong. It is implemented in primary and secondary schools through the Science, Technology and Mathematics KLAs set by EDB. KLAs organize the school curriculum around fundamental concepts of eight major knowledge domains, and the learning subjects in schools are grouped under these eight KLAs.

10 Other measures proposed include enhancing the training of teachers, promoting student-centred STEM learning activities, and strengthening partnerships with key stakeholders in the community.

11 As regards resources allocated to the promotion of STEM education, they included the disbursement of one-off grants to public sector primary and secondary schools in 2015-2016 and 2016-2017 respectively; a commitment of HK$500 million to implement the "IT Innovation Lab in Secondary Schools" initiative in all publicly-funded secondary schools in 2019; and the provision of funding support by the Quality Education Fund for schools to implement school-based initiatives on STEM education. Meanwhile, EDB has also arranged to provide diversified school-based professional support and intensive STEM-related training programmes for the leadership tier and middle managers of all primary and secondary schools.

covered in the "Primary School 2018 Profiles". While 62% of them reported that they had promoted STEM education in the school, they had chosen different STEM-related learning activities, ranging from teaching of coding and 3D printing technology to exchange programmes in STEM study with overseas countries.[12]

2.5 Another problem with the "school-oriented" policy is that the efforts to promote STEM education are planned by schools themselves. The way the STEM programmes are implemented in a school depends on, among other things, the resources available and committed, the length of class sessions allocated for STEM, expertise of individual teaching staff, and any industry partners the school can find in helping the design of STEM learning activities. As such, some schools inevitably encounter problems and obstacles when implementing STEM education.

2.6 Indeed, there are many obstacles to overcome in the implementation of STEM education, and the main challenge is the availability of time in schools. STEM is not a separate subject, and the teaching schedule in some schools is so tight that squeezing time for STEM education will mean the sacrifice of time for teaching other subjects[13]. At present some schools organize STEM activities as after-school programmes. There are some others which limit STEM activities to those students who are talented in the area, rather than a programme targeted at every student.

2.7 Furthermore, school teachers are discipline-based and hence not trained to teach interdisciplinary STEM education. Added to this, primary schools have followed EDB's curriculum guideline by integrating STEM elements into General Studies and Computer courses. Some General Studies teachers are not a science major and teaching STEM lessons is a new challenge for them[14].

2.8 Surveys conducted by various organizations over the past few years have attested to the problems and obstacles encountered by schools and/or teachers when implementing STEM education (**Figure 3**). These include insufficient lesson time for STEM education, teachers without enough expertise, confidence and support in teaching STEM, and vague teaching guidelines.

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[12] See 明報 (2018) and Tang (2019).

[13] See 陳文豪 (2018).

[14] See RTHK (2017).

Figure 3 – Obstacles to implementing STEM education under "school-oriented" approach

Crouncher Foundation (June 2015-May 2016[(1)])

- Teachers too busy with teaching and administrative duties and not so willing to spend time/effort on STEM activities.
- Senior secondary students too busy to join STEM activities.
- Some teachers without specific knowledge on certain STEM subjects (such as robotics and coding).

Hong Kong Federation of Youth Group (November-December 2017[(1)])

- Insufficient lesson time for STEM education (75.7% of responded schools[(2)]).
- Difficulty in developing cross-subject STEM education (71.8%).
- Inadequate examples for school reference (57.3%).
- Shortage of teacher training (48.6%).
- Dissatisfaction on clearness of the STEM education relating teaching guidelines (48.5%).

Federation of Education Workers (October 2017[(1)])

- Not confident about teaching STEM subjects (63.6% of teacher respondents[(2)]).
- Not enough STEM training and support (83.3%).
- Not enough hardware equipment (81.6%).
- Not enough support for teaching materials (70.5%).

Amgen Asia and Global STEM Alliance (October 2017[(1)])

- Low priority given by schools to STEM subjects (44% of teacher respondents[(2)]).
- Not enough opportunities or support for teachers' professional development (>80%).

Chinese University of Hong Kong (summer of 2017[(1)])

- A mere 5.53% of teacher respondents regarding themselves as "well prepared" for STEM education.
- Teacher respondents citing intense concerns over STEM education, including availability of pedagogic support and organizing instructional activities to implement lessons smoothly.

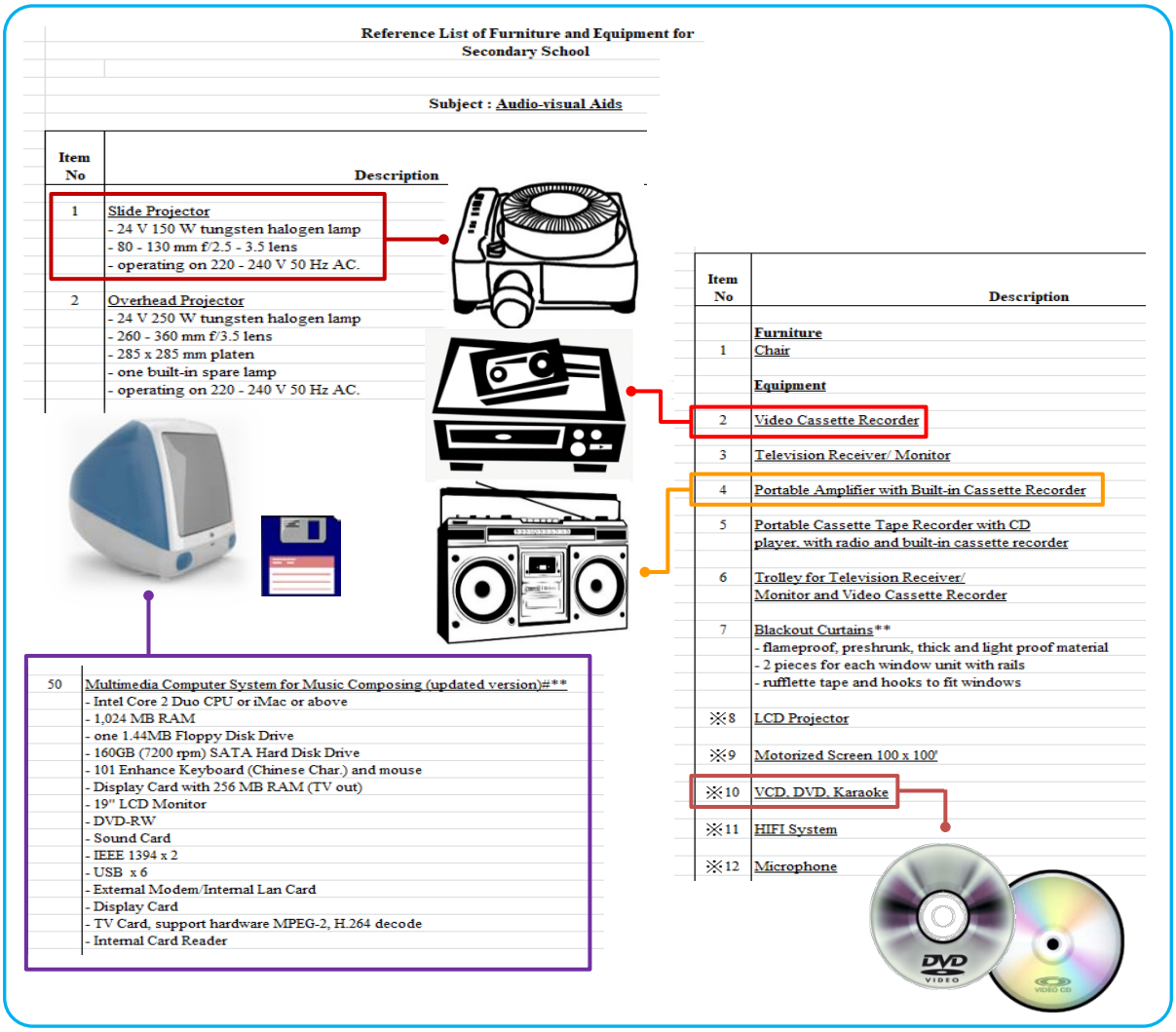
Notes: (1) Survey period.
(2) The figure represents the percentage of those respondent schools/teacher respondents who indicated "agree".

Sources: Croucher Foundation (2016), Hong Kong Federation of Youth Group (2018), 香港教育工作者聯會 (2017), Amgen Asia and Global STEM Alliance (2017), and Geng, J. et al. (2018).

Hardware for STEM education

2.9 In addition to "school-oriented" policy, the "Furniture and Equipment List for New Schools" published by EDB has also been criticized for not dovetailing with the policy of promoting STEM education in schools.[15] The list, updated in May 2020, is a reference list of furniture and equipment for new primary and secondary school premises. Some of the stated items, such as VHS video recorder, cassette player, computer with a floppy disk drive, and slide projector are outdated (**Figure 4**). In contrast, advanced machines such as 3D printer/scanner and laser cutter are not on the list.

Figure 4 – Reference list of furniture and equipment for new primary and secondary school premises



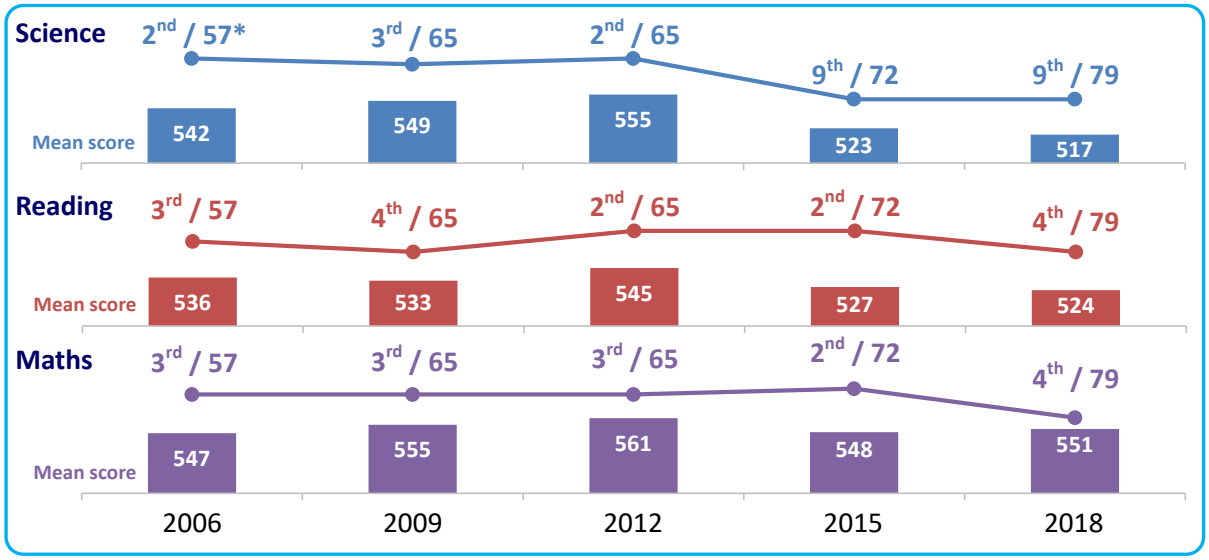
Source: Education Bureau (2020).

[15] See Mok (2018) and 香港 01 (2019).

Effectiveness of STEM education

2.10 STEM proficiency achieved by Hong Kong students can be measured by the results they obtain in the science test of the Programme for International School Assessment ("PISA")[16]. In the latest PISA 2018, Hong Kong remained ninth in scientific literacy after experiencing a marked decline in its ranking in science from second in PISA 2012 to ninth in PISA 2015 (**Figure 5**). However, the mean science score for Hong Kong students in PISA 2018 was 517, a 25-point drop from the mean score in PISA 2006.[17] This exceeded the average decrease in mean science score across all OECD economies by 19 points over the same period.[18] In Hong Kong, the percentage share of "high achievers[19]" in PISA science test also decreased by 8.1 percentage points between 2006 and 2018. This was the second largest decrease in "high achievers" in science of any PISA participating country or economy during 2006-2018.

Figure 5 – Hong Kong students' performance in PISA from 2006 to 2018



Note: (*) Number of PISA participating countries/economies.
Data source: Chinese University of Hong Kong (2019).

[16] PISA is organized by OECD and conducted every three years with a view to assessing students aged 15 of their competence in mother-tongue reading, mathematics and science. A total of 79 countries/economies participated in the latest PISA 2018.

[17] As the first major assessment of science, the 2006 assessment has been used to establish the basis for the PISA science scale.

[18] The mean science scores across all OECD economies were 495 and 489 respectively in the 2006 and 2018 PISA tests.

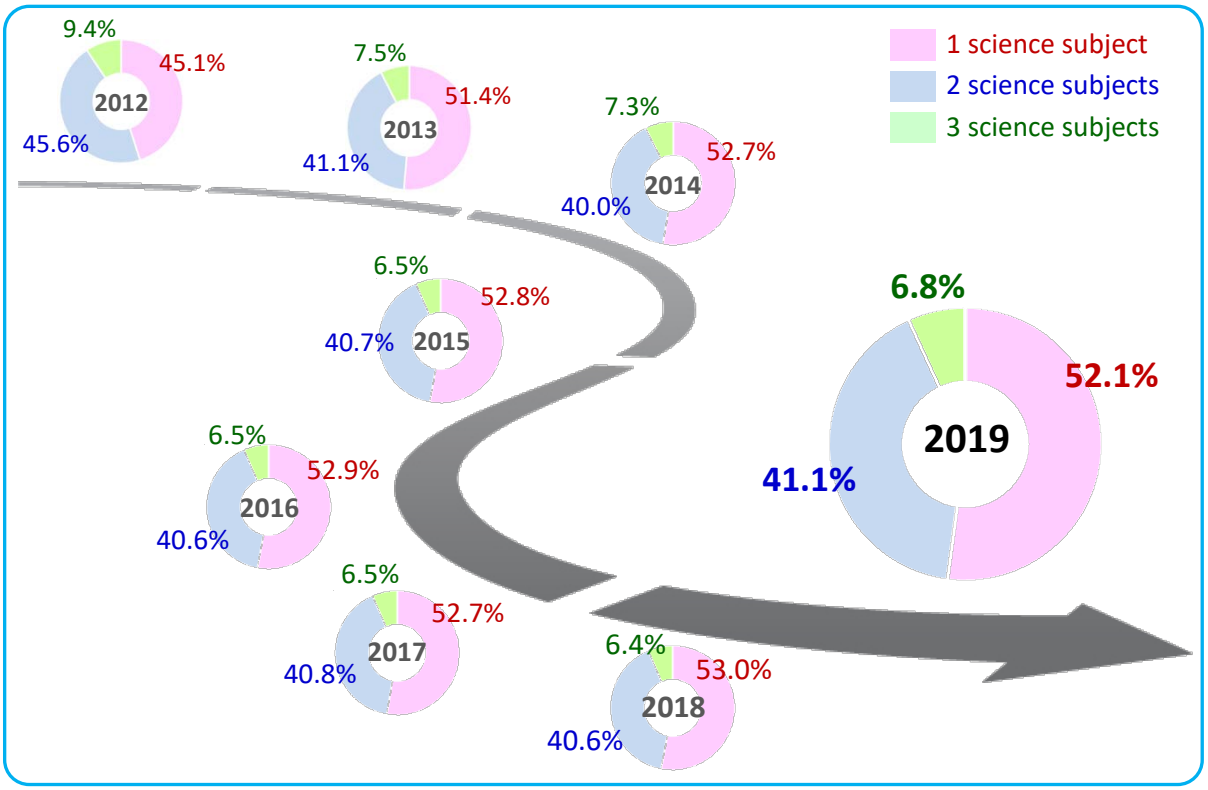
[19] "High achievers" refers to those students who attained Level 5 or above (633.33 points or higher) in the PISA science test.

2.11 In addition to the falling science performance in PISA, Hong Kong's secondary students fail to have a balanced introduction to STEM education[20] as evidenced by (a) the number of students pursuing Science subjects at secondary schools; (b) enrolment in advanced mathematics studies; and (c) students' decision on the number of electives to take at schools.

Science subjects

2.12 Mathematics is a core compulsory subject throughout the six-year secondary education in Hong Kong. Yet, Science subjects[21] are optional at senior secondary level, and as many as 50.5% of HKDSE Examination candidates did not take any Science subjects at all in 2019. Among those HKDSE candidates taking Science subject(s) in the examination, the majority took only one Science subject in 2109 (52.1%). The remaining 41.1% took two Science subjects and a mere 6.8% three Science subjects (**Figure 6**).

Figure 6 – Proportion of HKDSE candidates taking science subjects, 2012-2019



Data sources: Hong Kong Examinations and Assessment Authority.

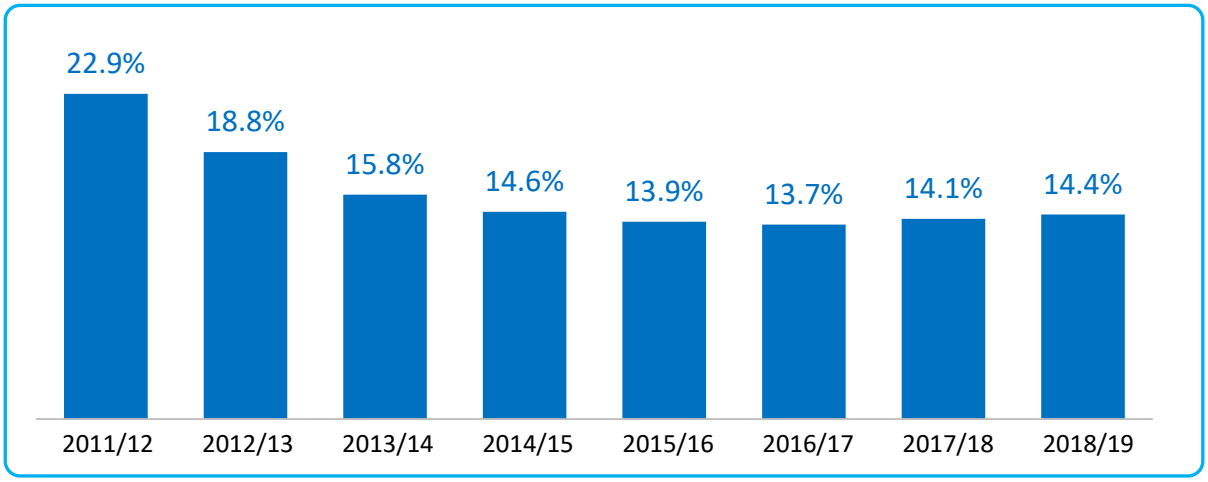
[20] See Wong (2017).

[21] In addition to conventional science subjects (Physics, Chemistry and Biology), EDB has introduced two new science subjects – "Combined Science" and "Integrated Science" – for Hong Kong Diploma of Secondary Education ("HKDSE") candidates.

Enrolment in advanced mathematics studies

2.13 Enrolment rate of Secondary Six students in advanced mathematics[22] has declined from 22.9% in 2011-2012[23] to 14.4% in 2018-2019 (**Figure 7**). Under the previous Hong Kong Certification of Education Examination ("HKCEE"), advanced mathematics was offered to students in the form of Additional Mathematics, and for students in matriculated studies for the Hong Kong Advanced Level Examination ("HKALE") in the form of Pure Mathematics and Applied Mathematics. In 2010, some 25% of HKCEE candidates took Additional Mathematics and around 25% of HKALE students enrolled into Pure Mathematics or Applied Mathematics.[24]

Figure 7 – Enrolment rate of Secondary Six students in advanced mathematics, 2011-2012 to 2018-2019



Data sources: Academy of Sciences of Hong Kong (2016) and Education Bureau (various years).

Students' decision on the number of electives to take at schools

2.14 EDB encourages students to take more elective subjects when ability permits so as to better equip themselves with multi-disciplinary knowledge/skills (a need in STEM education) for future studies and work.[25]

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[22] For HKDSE candidates, the subject of Mathematics consists of a Compulsory Part (basic mathematics) and an Extended Part (advanced mathematics). There are two modules in Extended Part: Module 1 (Calculus and Statistics) and Module 2 (Calculus and Geometry). Candidates entering HKDSE Mathematics can take the Compulsory Part only or the Compulsory Part with either Module 1 or Module 2 from the Extended Part.

[23] 2012 was a monumental year when the first cohort of Secondary Six students sat for the HKDSE Examination administered for the first time in March-May 2012.

[24] See Academy of Sciences of Hong Kong (2016).

[25] See Education Bureau (2019b).

In 2018-2019, 71.7% of Secondary Six students took two electives, and merely 19.1% took three electives. This contrasts with an average of 4.1 elective subjects taken by students under HKCEE and 2.3 elective subjects by HKALE students in 2010.[26]

2.15 The over-emphasis on the four core subjects might have discouraged students from taking more elective subjects. To enter UGC-funded universities, students are required to fulfil the general entrance requirements of undergraduate programmes with attaining "3322" in the four core subjects[27]. There are views that the four core subjects are too "heavy" in taking up 45%-55% of students' studying time, restricting them from taking more elective subjects.[28]

2.16 In addition to the "3322" general entrance requirement, the existing university admission mechanism also affects students' decision on the number of electives to take. Admission to the majority of undergraduate programmes currently requires scores from six subjects at most[29], so some senior secondary students might "strategically" study two elective subjects even if they are capable of choosing more elective subjects.

3. STEM education in international comparison

3.1 Hong Kong has invested a lot of resources in STEM education. The situation is no different from other developed economies which have also made significant investments in STEM educational initiatives, driven by the concerns over potential shortfalls in STEM qualified professionals in the future. **Figure 8** below highlight the relevant experiences of the US, the United Kingdom ("UK"), South Korea, Australia and Singapore with governments giving different emphases to promoting STEM education. Singapore is studied in greater detail in view of the comprehensiveness of its government efforts to formulate STEM support measures on various fronts.

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[26] See Academy of Sciences of Hong Kong (2016).

[27] General entrance requirement of undergraduate programme means attaining a minimum of Level 3 for both Chinese Language and English Language, and Level 2 for Mathematics and Liberal Studies (i.e. "3322"), plus requirements for one to two electives in the HKDSE Examination.

[28] See Education Bureau (2019b).

[29] Currently, majority of undergraduate programmes offered at the UGC-funded universities use "4C+2X" (four core subjects and two electives), "Best 5 subjects", or "Best 6 subjects" to consider candidates' admission. In 2019, only the Faculty of Medicine of the Chinese University of Hong Kong ("CUHK") strongly recommended applicants to take a third elective in HKDSE Examination.

Figure 8 – Focus of STEM education policy in selected places

Promotion by federal legislation of specific areas of STEM education

- The 2009 American Recovery and Reinvestment Act provides for establishing a dedicated government agency, the Committee on STEM Education (CoSTEM), to co-ordinate federal efforts related to STEM. CoSTEM is charged with developing a STEM education strategic plan to be update once every five years.
- The 2015 Every Student Succeeds Act prioritizes STEM education, including establishing a Master Teachers Corps programme. The programme recruits outstanding STEM teachers to model lessons and mentor younger teachers.

Community support through STEM Ambassador Programme and Science Learning Partnership

- STEM Ambassadors are volunteers from a wide range of STEM-related jobs/disciplines across the UK, offering their time/experiences to encourage young people to progress in STEM subjects through presentations, mentoring and career talks.
- Science Learning Partnership brings together local expertise in England to provide support for science teaching at primary and secondary schools through best practice guidance, online resources, and continuing professional development for teachers.

Providing teacher supports through national STEAM PD (professional development) and STEAM RGT (research group of teachers) programmes

- In South Korea, the government focuses on STEAM education which is an interdisciplinary approach that incorporates the field of arts into STEM education.
- Three-step STEAM PD programme comprising (a) "Introductory Training" helping teachers understand basic concepts of STEAM education; (b) "Basic Training" getting teachers familiar with the best practices of STEAM teaching; and (c) "Intensive Training" developing teachers' competency in creating STEAM contents for teaching.
- STEAM-RGT programme: government encouraging teachers to form voluntary self-guided learning communities to conduct research on STEAM education and share the results with other communities.

Formulation of a national strategy

- The National STEM School Education Strategy 2016–2026 sets out the goals and actions of ensuring (a) all students finish school with a solid foundation of STEM knowledge and skills for application; and (b) students are inspired to take on more challenging STEM subjects (e.g. advanced mathematics).

Establishment of a dedicated agency for improving the quality of STEM teaching

- STEM Inc, established under Science Centre Singapore, is specifically entrusted with supporting secondary schools in developing and implementing STEM.

Sources: Various government websites.

Promotion of STEM education in Singapore

3.2 In Singapore, STEM is part of the Applied Learning Programme ("ALP")[30] that the Ministry of Education ("MOE") has been promoting since 2013 to train secondary school students on interdisciplinary knowledge and the application of academic knowledge and skills to real-world. To support STEM APL, MOE has partnered STEM Inc[31], a newly established unit under Science Centre Singapore[32] . In the first phase of the implementation of STEM ALP in 2014, 19 schools embarked on the programme. Currently, some 66 or half of mainstream secondary schools are offering STEM ALP.

3.3 STEM Inc proactively supports secondary schools in developing and implementing STEM education, in contrast with the "school-oriented" approach in Hong Kong where the efforts are planned by schools themselves. The efforts made by STEM Inc, as highlighted below, might help shed light on addressing some of the obstacles encountered by Hong Kong's schools/teachers when implementing STEM education[33].

Educating students with a structured STEM curriculum

3.4 In Singapore, the STEM ALP curriculum is designed by specialists STEM Inc recruited from outside the formal school education system. Some of these specialists are retired professors or engineers, while some others are younger specialists with years of R&D experience. This is significant because most STEM teachers in Singapore have limited or no exposure to the areas where scientists, engineers and other STEM professionals work. The background of STEM Inc's specialists, with prior industrial or R&D experience, can help bridge the knowledge and know-how gap in schools.[34]

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[30] ALP was one of the new programmes rolled out by the then Minister of Education in 2013 to equip students with the 21st century skills. The other programme, the Learning for Life Programme, aims to nurture students' character and values and develop their interpersonal skill.

[31] STEM Inc is the abbreviation for Science, Technology, Engineering and Mathematics, while "Inc" can be innovation and creativity or Incorporation.

[32] The Science Centre Singapore is a statutory board under MOE dedicated to the promotion of interest, learning and creativity in science and technology in Singapore.

[33] These obstacles include vague teaching guidelines, STEM learning activities limited to a few students who are talented in the area, as well as a lack of teaching support for schools and teachers.

[34] See Lim et al. (2018).

3.5 At present, 12 domains of STEM APL relevant to different industries are offered to STEM ALP schools.[35] MOE works closely with STEM Inc to advise schools on identifying a particular domain to which their STEM ALP is mostly aligned, based on the needs and aspirations of their students and teachers. While schools identify a particular domain for their STEM ALP, the interdisciplinary nature of the domain also means a school's programme can incorporate aspects from other areas of knowledge.[36]

3.6 Moreover, the STEM ALP is not structured as an afterschool programme in Singapore. The actual lessons and activities are conducted in the classroom as part of the school timetable. This, coupled with no examination in STEM ALP, allows the STEM learning activities to be seen not as an extra requirement or a burden by students and teachers.

Catering to different students with a three-tiered STEM ALP programme

3.7 The STEM ALP is designed with three tiers of programmes and engagement for students of different abilities and interest. This is based on the belief that all students should be given the opportunity to try and experience the fun and excitement of STEM[37]. The three-tier STEM ALP comprises:

(a) **Tier 1 programme (mass-based programme)** – compulsory for all Secondary 1 and 2 students who will go through interesting and innovative lessons and activities that demonstrate how they can use scientific knowledge to solve real life problems;

(b) **Tier 2 programme (interest groups)** – optional for senior secondary students who are keen to learn more. They can participate in extra-curriculum programmes, in the form of joining domain-specific STEM clubs (e.g. engineering clubs and environment clubs), participating in events such as the Singapore Science Festival, and pursuing project-based learning; and

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[35] These comprise (a) Embedded Electronics; (b) Engineering Design & Modelling; (c) Robotics; (d) Alternative Energy; (e) Food Science & Technology; (f) Urban Design & Innovation; (g) Water Sensors & Water Technology; (h) Materials Science; (i) eHealth Sensors; (j) Applied Health Sciences; (k) Flight & Aerospace; and (l) Game Design & Simulation.

[36] For example, in the eHealth Sensors STEM domain, basic biology and human physiology are introduced to students. Students will also gain hands-on experience working on electrical components and the coding required for functionality. The understanding and working knowledge of these components allow students to design their own solutions to healthcare challenges, such as aids for the visually impaired.

[37] See Lim et al. (2018).

(c) **Tier 3 programme (talent development)** – involves only a very niche group of students who wish to pursue applied learning opportunities, after experiencing the fun and excitement of STEM and aiming to develop a STEM career. Unlike in the Tier 2 programme, where students work in small teams, students in the Tier 3 programme are expected to be self-motivated and independent. STEM Inc will help to further their pursuit with providing the necessary equipment and facilities for them.

Supporting teachers and schools in STEM learning activities

3.8 The STEM ALP curriculum specialists and STEM educators employed by STEM Inc train teachers and work with them to **co-develop** and **co-teach** STEM lessons.[38] Under the MOE guidelines, STEM Inc is not to become a permanent service provider to schools.[39] In the early years, STEM Inc curriculum specialists and educators help STEM ALP schools by first teaching and then co-teaching the STEM ALP lessons in the classroom, while building up school teachers' capability to run STEM ALP. After a period of about two years, the schools will run STEM ALP programmes on their own, with STEM Inc playing a consultative role to ensure that each school's STEM ALP is kept up-to-date with local and global industry trend.

3.9 Every STEM ALP school is also matched with an industry partner in its STEM domain under the Industrial Partnership Programme ("IPP"). IPP is an initiative by STEM Inc featuring the involvement of industry partners in (a) advising schools on their STEM teaching programmes; (b) conducting industry visits and learning journeys for students, teachers and/or parents; (c) helping students on their careers aspirations through industrial attachment; and (d) organizing STEMchat for students to participate in a 30-minute web chat with three STEM professionals. The aim of IPP is to complement STEM ALP by creating opportunities for students to get early exposure to real-world STEM industries and careers, and for industry partners to promote STEM professionals.

[38] Teachers can be granted temporary leave by MOE for secondment to Science Centre Singapore. The secondment tenure is two years during which teachers will co-create curriculum, conduct research, mentor student research etc.

[39] See Lim et al. (2018).

4. Undergraduates pursuing STEM disciplines at universities

4.1 In addition to promoting STEM education in primary and secondary schools, attracting students with high academic achievements to pursue a STEM-related undergraduate degree is also crucial to building a strong local talent base for Hong Kong. However, STEM programmes at UGC-funded universities fail to attract students with the best academic results, due to the concerns over the limited job prospects upon graduation and weak R&D spending in Hong Kong.

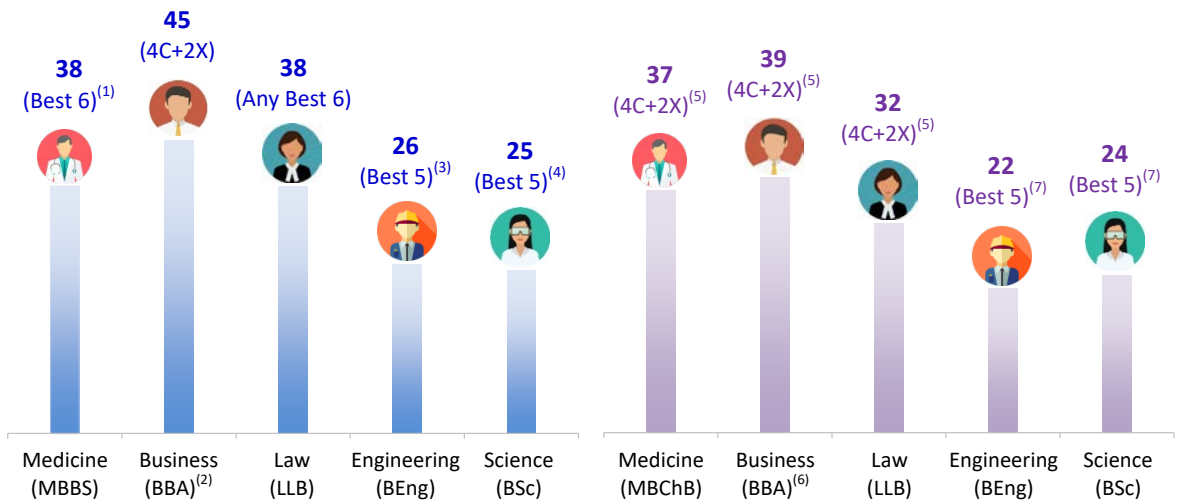
4.2 At present, the career prospects for STEM graduates are not particularly attractive. As a service-oriented economy and an international financial centre, Hong Kong relies more on financial and service industries rather on technology sector. Reflecting this, the traditional Four Key Industries in Hong Kong, including financial services, tourism, trading and logistics, and professional and producer services, have dominated Hong Kong's economic growth and job market. In 2017, they contributed to 57.1% of gross domestic product ("GDP") and 46.6% of total employment. In contrast, the innovation and technology industry only accounted for 0.7% of GDP and 1.0% of total employment.

4.3 The weak R&D spending might further weaken students' enthusiasm towards pursuing undergraduate STEM studies in Hong Kong. Hong Kong's gross expenditure on R&D ("GERD") as a percentage of GDP has been standing at a low of less than 1% since 2000, lagging behind many developed economies. In 2017, GERD accounted for 0.8% of Hong Kong's GDP, a ratio much lower that of South Korea (4.55%), Japan (3.21%) and Singapore (1.95%).

4.4 Against the above, many high-preforming students choose to study university degrees in medicine, business and law instead of STEM disciplines, which are considered to offer more attractive career prospects. In 2019, students admitted to those three disciplines at the University of Hong Kong ("HKU") and CUHK had median entrance scores that were higher than those admitted to the science and engineering disciplines (**Figure 9**).[40]

[40] According to Varsity (2017), the median admission scores of the engineering schools in Hong Kong are among the lowest of all programmes in some UGC-funded universities. Some students regard the engineering programme as a safety net in their university choice and may not be genuinely interested in engineering or science.

Figure 9 – Median entrance scores of selected disciplines in HKU and CUHK in 2019



Notes: (1) Requiring a specific elective subject which is one of the following at Level 3 or above: Chemistry or Combined Science with Chemistry component.

(2) Bachelor of Business Administration in International Business and Global Management.

(3) Requiring a specific elective subject which is one of the following at Level 3 or above: Physics or Combined Science with Physics component.

(4) Requiring a specific elective subject which is one of the following at Level 3 or above: Biology, Chemistry, Physics, Combined Science or Integrated Science.

(5) 4C+2X: (a) 4 core and best 2 elective subjects in Category A or Category C of HKDSE; or (b) 4 core and best 1 elective subject and M1/M2 in Category A of HKDSE. HKDSE subjects are divided into three categories, namely Category A made up of 24 senior secondary subjects (4 core subjects and 20 elective subjects); Category B (Applied learning subjects); and Category C (other language subjects e.g. Japanese and French).

(6) Bachelor of Business Administration in Global Business Studies.

(7) Best 5 subjects in Category A or Category C of HKDSE.

Data source: JUPAS (2019).

5. Students pursuing research postgraduate programmes at universities

5.1 In addition to STEM graduates, RPg students can add to the pool of talent Hong Kong needs for the New Economy. Yet, among RPg students of UGC-funded universities, the proportion of local students has been on the decline over the years from a high of 63% in 2002-2003[41] to 20% in 2018-2019. The concern over employment opportunities, particularly keen competition for

[41] From 2003-2004, no quota restriction was imposed on the admission of non-local students in RPg programmes by UGC-funded institutions.

university jobs in teaching/research fields[42], might have discouraged local elite students from pursuing RPg studies at UGC-funded universities.[43] Indeed, the unemployment and underemployment rates for RPg students have consistently higher than those of undergraduates, standing at a high of 4.2% and 5.8% respectively in 2017-2018.[44]

5.2 Non-local students have picked up the education opportunities left by local students, accounting for an increasing share of the total enrolment in RPg programmes at the UGC-funded universities. They accounted for 80% of total RPg student enrolment in 2018-2019. Such percentage share of non-local students is much higher than that in the UK and Australia[45], which are among the most favoured destinations for international students pursuing postgraduate studies.

5.3 Mainland students make up the largest group of non-local RPg students, at 83.3% in 2018-2019, despite the proportion decreased from a high of 93.9% a decade ago. They are attracted by the relatively lower tuition fees in Hong Kong, as compared with favourable overseas study destinations like the US and the UK. Hong Kong's academic reputation and proximity to the Mainland are also attractive factors.

5.4 A high degree of internationalization of higher education should help meet talent demand in Hong Kong if non-local students stay and work in the territory after graduation. With a similar cultural background, Mainland students are a particularly attractive and feasible potential source of talent for Hong Kong. Yet, local talent admission scheme has met with limited success due to Hong Kong's high cost of living and relatively low attractiveness as a liveable city for expatriates.[46] For engineers and scientific researchers, the relatively small share of manufacturing sector in Hong Kong's GDP might further adversely affect their decision to work and settle in the territory. In particular, the domestic market is too small to provide the scale efficiency required for commercializing their research results and inventions.

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[42] See 無綫新聞 (2018) and 香港 01 (2017) & (2018).

[43] There are some local graduates choosing to undertake RPg studies at overseas universities to experience conducting research under a different culture and environment.

[44] In comparison, the unemployment and underemployment rates for undergraduates were 2.0% and 5.0% respectively in 2017-2018.

[45] The corresponding figures for the UK and Australia were 41.5% (2017-2018) and 34.7% (2018).

[46] For a detailed discussion of Hong Kong's talent admission schemes , please refer to the Research Brief *Global competition for talent* published by the Research Office in June 2020.

6. Continuing education in Hong Kong

6.1 The Government set up the Continuing Education Fund ("CEF") in June 2002 to subsidize people to pursue continuous education and training programmes. Eligible applicants may submit unlimited number of claims for reimbursement of fees up to a maximum sum of HK$20,000 within one year upon successful completion of CEF reimbursable courses and before reaching the age of 71[47].

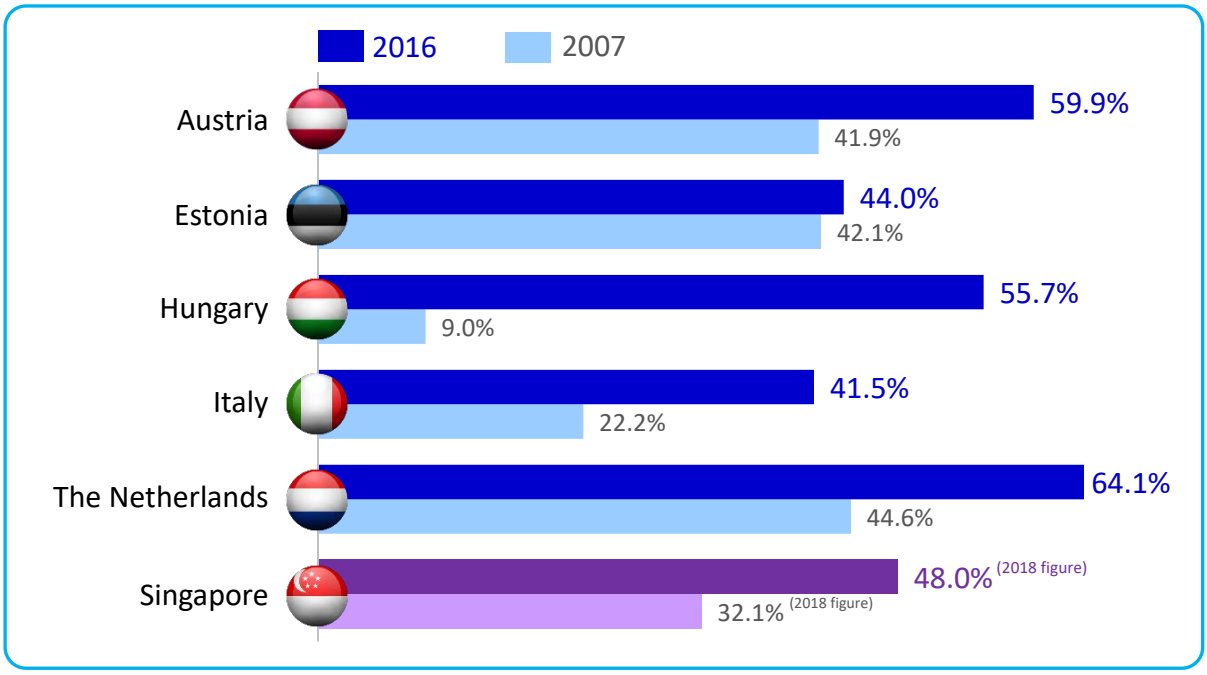
6.2 Notwithstanding the establishment of CEF, the continuing education participation rates in Hong Kong have remained relatively low over the years. According to a survey conducted by the Census and Statistics Department in 2018, of the 3 689 100 economically active persons, only 20.4% had attended job-related training/retraining courses arranged by employers and/or on their own initiative during the 12 months before enumeration[48]. This participation rate represented a modest improvement from that of 14.6% obtained from a similar survey conducted in 2002.

6.3 Internationally, Hong Kong also compares unfavourably with many developed economies in terms of the participation rate in continuing education. In 2020, OECD published a report on adult learners which identifies six countries characterized by a relatively high participation rate in adult learning (**Figure 10**). Among them, Singapore has been recognized by OECD as a successful example of incentivizing firms and individuals to invest in continuing education through its SkillsFuture movement.

[47] The lifetime maximum subsidy had been remained unchanged at HK$10,000 since its inception in 2002, and it was not until April 2019 that the Government raised the ceiling to HK$20,000.

[48] Of those economically active persons aged 15-24, 25-34 and 35-44, only 14.3%, 21.4% and 22.8% respectively had attended job-related training/retraining courses arranged by employers.

Figure 10 – Participation in formal/non-formal job-related training in the past 12 months of 15-64 years-old



Data source: Organisation for Economic Co-operation and Development (2020a).

SkillsFuture in Singapore

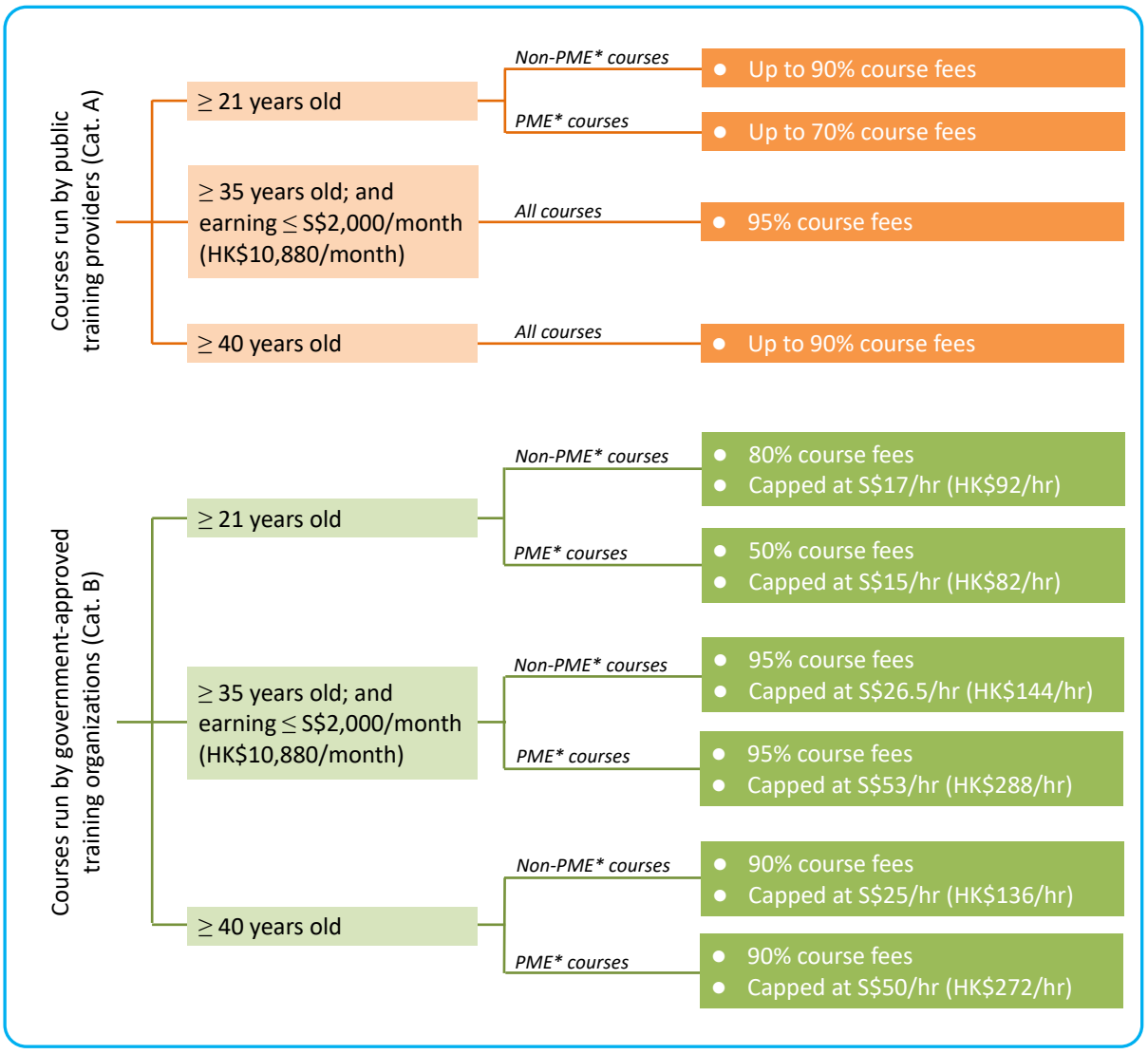
6.4 In Singapore, the government implemented a nationwide movement – SkillsFuture – in 2015 to promote lifelong learning through acquisition and updating of skills. It aims to provide Singaporeans with the opportunities to develop their fullest potential throughout life, regardless of their starting points and education levels. To implement the SkillsFuture movement, the government increased its spending on continuing education and training programmes from S$600 million (HK$3.3 billion) per year during 2010-2015 to over S$1 billion (HK$5.4 billion) per year during 2015-2020.

6.5 As part of SkillsFuture, every Singaporean aged 25 and above is given an individual learning account and S$500 (HK$2,720) in SkillsFuture Credit. The Government will make further top-ups to their SkillsFuture Credit accounts at regular intervals. For example, the Government announced in February 2020 that a one-off SkillsFuture Credit top-up of S$500 (HK$2,720) will be given to every Singaporean aged 25 and above as at December 2020 to encourage them to learn new skills. The SkillsFuture Credit can be used on top of existing government subsidies to pay for a wide range of approved

skills-related courses[49] in eight priority and emerging skills areas, comprising eight categories under the SkillsFuture Series: (a) Data analytics; (b) Finance; (c) Tech-enabled services; (d) Digital media; (e) Cybersecurity; (f) Entrepreneurship; (g) Advance manufacturing; and (h) Urban solutions.

6.6 The Singapore government also supports continuing education through generous subsidies it offers to approved courses, in a further effort to make continuing education more affordable to mass of citizens. Course fee subsidies range from 50%-95% for self-sponsored individuals (**Figure 11**).

Figure 11 – Course subsidy for self-sponsored individuals



Note: (*) PME courses are courses at the professional, managerial, executive level.
Data source: SkillsFuture (2020).

[49] For example, if the course fee is S$1,000 (HK$5,600) and the government subsidies 90% of the course fee, the student can use his or her SkillsFuture Credits to pay for the net course fees of S$100 (HK$560).

6.7 For employer-sponsored training, the government provides the same range of course subsidies of 50%-95% to the employers. Employers are also entitled to receive Absentee Payroll funding[50] at 80% of an employee's basic hourly salary, capped at S$7.5 (HK$40.8) per hour for small and medium enterprises ("SMEs") and S$4.5 (HK$24.5) per hour for non-SMEs. Companies can also apply for Absentee Payroll funding at 95% of hourly basic salary of those employees earning not more than S$2,000 (HK$10,880) per month and aged 35 or above under the Workfare Training Support Scheme.

7. Observations

7.1 The following observations are made based on the findings above:

(a) Hong Kong is lagging behind many developed economies in nourishing local talents. Cultivating STEM literacy in primary and secondary schools, as well as attracting more elite students pursuing STEM programmes at universities, should help boost the supply of local talent for the New Economy. Building a local talent pool from RPg students also contributes;

(b) while nurturing local talent starts with education at schools and universities, one's learning can and does occur beyond the formal structure of an educational institution. The rapidity of technological advance makes it no longer feasible to equip learners through traditional schooling with all the skills they need to prosper through their lifetime career. The need for continuing education has never been more important for talent to adapt to the accelerating changes to jobs brought about by technological advance;

(c) the Government has invested a lot of resources in STEM education, but its "school-oriented" approach has been criticized for being too "loose". In addition, the efforts to promote STEM are planned by schools themselves under the "school-oriented" schools. Some schools and teachers have inevitably encountered problems and obstacles when implementing STEM education, which include vague teaching guidelines, and teachers without enough experience, confidence and support;

[50] Absentee Payroll funding is a grant to help employers defray the manpower costs incurred when they send their employees for certifiable skills training during working hours.

(d) probably reflecting the above, Hong Kong remained ninth in scientific literacy in the latest PISA 2018, after experiencing a marked decline in its ranking from second in PISA 2012 to ninth in PISA 2015. In addition, half of 2019 HKDSE candidates had no exposure to a science subject. Furthermore, enrolment rate of Secondary Six students in advanced mathematics declined from 22.9% in 2011-2012 to 14.4% in 2018-2019. Added to the above, 71.7% of the students sitting the HKDSE Examinations took only two electives due to overemphasis on the four core subjects;

(e) other developed economies have also made significant investment in STEM educational initiatives. In particular, Singapore's Ministry of Education has partnered STEM Inc in developing and implementing STEM ALP. The STEM curriculum is designed by STEM Inc specialists comprising retired professors, engineers, and young specialists with R&D experience. They help train teachers and work with them to co-develop and co-teach STEM lessons. STEM ALP learning activities are based on a three-tiered approach to cater to different students, and they conducted as part of school timetable and deliberately designed with no examination associated to them. This allows the STEM learning activities not to be seen as an extra requirement or a burden by students and teachers;

(f) on top of promoting STEM education in primary and secondary schools, attracting students with high academic achievements to pursue a STEM-related undergraduate is also crucial to building a strong local talent base. In Hong Kong, many elite students choose to study medicine, business and law instead of STEM in universities, as the former disciplines are considered to offer more attractive career prospects;

(g) postgraduate students are potential research professionals who can form a strong local talent base. Yet, places on RPg programmes at UGC-funded universities have been filled largely by Mainland students, who are a feasible potential source of talent for Hong Kong should they stay and work in the territory after graduation. Yet, local talent admission schemes have met with limited success due to Hong Kong’s high cost of living and low competitiveness as a liveable city for expatriates;

(h) notwithstanding the increasing need for acquiring new knowledge and skills throughout one's career life, the continuing education participation rates in Hong Kong have been relatively low in recent years. In Asia, Singapore has been identified by OECD as a successful example of incentivizing firms and individuals to invest in continuing education through its SkillsFuture movement; and

(i) Singaporeans are provided with SkillsFuture Credit to pay for approved courses and the Singaporean government will periodic top-ups. Generous government subsidies are also provided for self-sponsoring and employer-sponsoring courses, and employers are entitled to Absentee Payroll funding as well.

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