Towards universal participation in post-16 mathematics: lessons from high-performing countries

Country profile: Singapore

Population[1] (2010 Census):	3.77 million[2]
Population aged 5-19:	723800 (19%)[2]
Population aged 15-19:	263800 (7%)[2]
Registered school students[3] (Primary 1 to Post-secondary in 2010):	616515[4]
Number of schools[5] (Primary 1 to Post-secondary education in 2010):	364[4]
Enrolment in Post-secondary educational institutions[6]	138221[4]
Number of schools offering Post-secondary education in 2010:	31[4]

- Primary schools cover Primary 1 – Primary 6 (ages 6+ to 11+)
- Secondary schools cover Secondary 1 – Secondary 4/5[7] (ages 12+ to 15+/16+)
- Mixed level schools offer Primary and Secondary education (Primary 1 to Secondary 4/5), Secondary and Pre-university education (Secondary 1 to Junior College (JC) 2) and Upper Secondary to Pre-university education (Secondary 3 to JC2)
- Post-secondary education covers Pre-university education (JCs, Centralised Institute, Institutions[8] offering Integrated Programmes[9] (IP)), Polytechnics, Institute of

[1] Resident population comprises Singapore citizens and permanent residents.
[2] http://www.singstat.gov.sg/pubn/reference/yos.html
[3] Full-time enrolment; exclude university level, private education institutions, and foreign system schools and international schools which follow guidelines from their home country.
[4] Education Statistics Digest 2011: http://www.moe.gov.sg/education/education-statistics-digest/files/esd-2011.pdf
[5] Exclude university level, private education institutions, and foreign system schools and international schools
[6] Full-time enrolment only.
[7] Students in the Normal Academic (or Technical) Stream generally take four years to complete GCE N(A) level (or GCE N(T) level) and those who performed well can choose to study one more year (two more years) to complete the GCE 'O' level while those in the Express Stream generally take four years.
[8] These institutions also admit students with GCE 'O' level results for their pre-university courses.

Technical Education (ITE), LASALLE College of the Arts, and Nanyang Academy of Fine Arts (NAFA)

Note: JCs will be used to refer to Junior Colleges and Institutions offering two-year pre-university (i.e. upper-secondary) courses in this profile.

Singapore has a centralised education system. The education system features a national curriculum, with national examinations at the end of the Primary 6, Secondary 4/5 and JC2 (or equivalent). The national examination at the end of Primary 6 is a placement examination which assesses students' suitability for different streams at the secondary level. There are three streams at the secondary level:

- Express (60% of students)
- Normal Academic (NA) (25% of students)
- Normal Technical (NT) (15% of students)

The Express course is a 4-year programme culminating with the Singapore-Cambridge General Certificate of Education Ordinary Level (GCE 'O' Level) Examination. The NA stream is a 4-year programme leading to the GCE Normal (A) Level Examination. In the NA stream, students study a range of subjects similar to students in the Express stream and NA students who do well will proceed to take the GCE 'O' Level in the following year. Selected students[10] in the NA course may offer up to 2 'O' Level subjects at Secondary 4 or bypass the 'N' Level Examination to take the 'O' Level Examination in Secondary 5. The NT stream is a 4-year programme, with technical emphasis, leading to GCE 'N' (T) Level Examinations.

In recent years, Singapore has moved towards a more *flexible* and *diverse* education system[11]. In 2004, Integrated Programmes (IP)[12] was introduced to provide academically strong students with the choice to bypass the GCE 'O' Level examination and to progress directly from secondary to pre-university education. From 2013, NA students who do well at the GCE 'N' Level Examination can opt for "through-train" pathway[10] to the Polytechnics (top 10%) and the next 20% can opt for ITE Direct Entry Scheme instead of taking GCE 'O' Level in Secondary 5. Students in the ITE Direct Entry Scheme with a qualifying grade point average will be given a place in a related Polytechnic course.

Though the national examination is a high-stakes assessment used for placement and selection of students by different institutions, the Ministry of Education (MOE) recognises that there is a wide range in students' achievements and talents other than those assessed

[9] In 2004, Integrated Programmes (IP) was introduced to provide academically strong secondary students with the choice to bypass the GCE 'O' level examination and to progress directly from secondary to pre-university education.
[10] http://www.moe.gov.sg/education/secondary/normal/changes/
[11] http://www.moe.gov.sg/education/
[12] IP are offered in mixed level schools and consortium schools. Mixed level comprises Secondary 1 to JC 2 and Secondary 3 to JC 2. In consortium schools, students complete four years of secondary education in one school and are then transferred to the JC partner school for pre-university education.

in the national examinations and has introduced direct school exercises[13] where selected secondary schools, JCs, Polytechnics and universities have the flexibility to admit a certain percentage of students based on their school-based admission criteria.

1. What are the optional/compulsory upper secondary mathematics options?

→ Is upper secondary education compulsory or optional?
→ What is the structure of upper secondary programmes?
→ Is any mathematics compulsory in the upper secondary age group?
→ What, if any, are the mathematics options in upper secondary education?

Education is compulsory in Singapore for all children from the age of 6 to 15 years. The Compulsory Education Act provides for compulsory primary education for all Singapore citizens but upper-secondary education is not compulsory. All citizens of Singapore residing in the country have to attend a national primary school unless he/she has been exempted for compulsory education, e.g. a child receives home school or a child with special needs.

Singapore has a low attrition rate before the end of secondary schooling at 1.5% in 2008[14]. On completing secondary education, over 93%[15] of the Primary 1 cohort progress to post-secondary education. Post-secondary (upper-secondary equivalent) education in Singapore can be broadly divided into the following options - pre-university education at JC/CI/IP, vocational education offered by Polytechnics and ITE, and creative arts education at LASALLE and NAFA. Table 1 below shows the level of full-time enrolment in post-secondary education.

Table 1: Enrolment of students in Post-secondary education[16]

Institution	**Enrolment (%)**		
	2008	**2009**	**2010**
ITE	24593 (18.6)	24846 (18.3)	24789 (17.9)
Polytechnics (Diploma)	71137 (53.7)	74566 (55.1)	76989 (55.7)
JC/Centralised Institute/IP	32579 (24.6)	32110 (23.7)	32420 (23.5)
LASALLE and NAFA (Diploma)	4077 (3.1)	3915 (2.9)	4023 (2.9)
Total	132386 (100)	135437 (100)	138221 (100)

Upon completion of secondary schooling (lower-secondary equivalent), students apply to a JC for a 2-year pre-university course or the centralised institute for a 3-year course. Secondary students in IP progress to pre-university education without taking the GCE 'O' Level Examination. IP aims to provide a broader learning experience for *university-bound* students and the MOE targets that about 10%[17] of each cohort will be enrolled in IP. The

[13] In direct school exercises, participating schools/institutions select their students for admission before the national examination results are released.
[14] http://www.moe.gov.sg/media/speeches/2009/02/11/fy-2009-committee-of-supply-de-4.php
[15] http://www.moe.gov.sg/media/speeches/2012/03/08/fy2012-committee-of-supply-debate-2nd-reply.php
[16] Data taken from Education Statistics Digest from 2009 to 2011.
[17] http://www.moe.gov.sg/media/speeches/2003/sp20030320b.htm

culminating examination for the pre-university course is the GCE Advanced Level ('A' Level) Examination with two of the IP offering curricula which culminate in different qualifications (International Baccalaureate (IB) Diploma and National University of Singapore (NUS) High School Diploma).

Students in pre-university institutions may choose from a range of courses in different areas such as Humanities and the Arts, Languages, and Mathematics and Sciences. Students are required to offer at least one contrasting subject, i.e. a Science student has to offer a subject from the Humanities and the Arts, and vice versa. Students in pre-university education leading to the GCE 'A' Level Examination offer subjects at three levels – Higher 1 (H1), Higher 2 (H2) and Higher 3 (H3). H1 subjects aim to offer students with foundational knowledge in the subject areas to support them in their further studies at university level. According to the Ministry, H1 subjects are not "easy options" with shallow exploration of the subjects, rather, the content covered in H1 is half of H2 but similar in depth. H2 subjects are designed for students who may carry on further learning in the subject areas while H3 subjects aim to provide students with diverse learning opportunities for in-depth study of subjects offered at H2 level. Typically, students take 3 H2 and 1 H1 content-based subjects together with a General Paper or Knowledge & Inquiry, Mother Tongue and Project Work. Students with the ability and interest may offer an additional H1 or H2 subject or up to two H3 subjects[18].

In the IB Diploma, students are required to take six subjects chosen across six groups[19]: Language, Second Language, Individuals and Societies, Experimental Sciences, Mathematics, and Arts. The option is given to students to offer an additional subject from the first four subject groups or Computer Science in the Mathematics Group instead of a subject from the Arts group. Subjects in IB are offered at two levels: Standard and Higher. At least three, but not more than four, of the six subjects selected are taken at Higher Level (HL) and the others at Standard Level (SL). In addition to the subject requirements, each student has to fulfil three core requirements: Extended Essay, Theory of Knowledge, and Creativity, Action and Service.

The NUS High School of Math and Science, a specialised independent school, provides a six-year education for talented math and science students starting at Secondary 1. The school adopts a modular system and students can select modules across various subject areas so as to have a broad-based exposure or select modules that cover the same subject area to delve in depth. In the fifth and sixth years, in addition to English Language, Mother Tongue[20] and an Advanced Research Project, students have to read three compulsory major subjects of which one of them has to be mathematics and the other two can be chosen from any one of the sciences[21]. Students with ability and interest can offer a fourth major in science subjects or from the Arts and Humanities. Students are also given the

[18] http://www3.moe.edu.sg/cpdd/alevel2006/experience/sub_comb.htm
[19] http://sites.acsindep.edu.sg/ib/ib2010/
[20] For students who have not meet the minimum mother tongue requirement in the fourth year.
[21] http://www.highsch.nus.edu.sg/userfiles/file/Programme%20Of%20Studies%202012/Programme%20of%20Studies%202012%20_Public%20Version_12.01.06.pdf

opportunity to take undergraduate courses which provide them with tertiary learning experience and NUS credits. The school also encourages students to sit for Scholastic Aptitude Test (SAT) and Advanced Placement (AP) Examinations. Students from NUS High School graduate with the school's own diploma.

Secondary school graduates who want a more applied education can apply to the Polytechnics or ITE. The five Polytechnics (Singapore Polytechnic, Nanyang Polytechnic, Temasek Polytechnic, Ngee Ann Polytechnic and Republic Polytechnic) offer a range of 3-year diploma courses in areas of Applied Arts, Architecture & Building, Business & Administration, Education, Engineering Sciences, Health Sciences, Humanities & Social Sciences, Information Technology, Legal Studies, Mass Communication & Information Science, Science & Related Technologies, and Services. The ITE offers technical-based and vocational courses which lead to National ITE Certificate (Nitec) and Higher National ITE Certificate (Higher Nitec) in areas of Applied & Health Sciences, Business & Services, Engineering, Electronics & Info-Com Technology, and Design & Media. Close to 90% of the ITE graduates are employed within six months of graduation and about one-fifth move on to the Polytechnics to pursue further studies[22]. In collaboration with overseas institutions, ITE also offers Technical Diploma courses to provide its graduates with further upgrading opportunities. Secondary school graduates who are keen in the creative arts can apply to LASALLE or the NAFA, which offer three-year diploma courses in visual and performing arts.

Mathematics is not compulsory for students taking the GCE 'A' Level. Students can offer mathematics at H1 or H2 level and those who are advanced in mathematics and with the passion and interest can take mathematics at H3 level to pursue mathematics in a greater depth together with H2 mathematics[23]. H1 mathematics aims to provide students with foundational mathematical knowledge to pursue further studies in areas which require a degree of competence in mathematics to understand other subjects while H2 mathematics is designed for students who may engage in mathematics related fields or mathematics in its own right. A high percentage of the students taking the GCE 'A' Level would take H2 mathematics and a small percentage of high mathematics achievers would take up H3 mathematics. Students who are less mathematically inclined might take H1 mathematics if mathematics is a requirement in the university course that they might want to pursue.

Mathematics is compulsory for students in IP offering the IB curriculum and the NUS High School. There are four different mathematics options[24] in the IB programme:

- *Mathematics Studies (SL)* - for students who want to have a better understanding of the relevance of Mathematics
- *Mathematics (SL)* - for students who need to gain competence in Mathematics to understand other subjects
- *Mathematics (HL)* - for those who intend to pursue further studies in mathematics or areas related to mathematics
- *Further Mathematics (SL)* - for those who intend to pursue further studies in mathematics or areas related to mathematics

[22] http://www.moe.gov.sg/media/speeches/2011/03/07/fy-2011-committee-of-supply-de-3.php
[23] All H3 subjects must be offered together with their H2 corresponding subjects.
[24] http://sites.acsindep.edu.sg/dsayear5/2012/IB%20Subjects%20Offerings.pdf

In the NUS High School[25], students who have consistently performed well can read mathematics offered at pre-university level in earlier years and may qualify to read mathematics with Honours in the fifth and sixth years. In addition, there are three AP mathematics options for students: two in Calculus and one in Statistics.

For students in the ITE and Polytechnics, students' participation in Mathematics, Statistics, Calculus or Accounting is dependent on course requirements. For examples, in the Polytechnics, all Diploma courses in Engineering Science have different levels of Engineering Mathematics as compulsory modules, Diploma courses in Tourism and Resort Management has Business Statistics as a required module, and Diploma in Psychology Studies has Statistics and Quantitative Research Methods as required modules. In the ITE, the emphasis on mathematics courses is more on application rather than theory.

2. What are the current and past student participation levels in these options?

- → What are current levels of participation in mathematics options amongst the upper secondary cohort and age group?
- → What are the current levels by gender?
- → How do these participation rates changed over time?

About 28%[26] of the Primary 1 cohort was admitted into pre-university courses from 2008 to 2010. A detailed breakdown of student participation in mathematics options in different courses is not available. Based on the percentage of students in Science courses as an estimate, 82% of pre-university students may have taken up H2 mathematics in 2011, higher than that estimated in the previous report (2010)[27] - about 80%[28] of the students in the 'A' Level cohort in 2009 took mathematics. An estimated 10% or less may have offered H3 mathematics. This estimate is based on the percentage of the pre-university cohort offering the 'Special Paper' in the old 'A' level syllabus.

About 43%[29] of the Primary 1 cohort was admitted into the Polytechnics from 2008 to 2010. Table 2 shows the Polytechnics' intake during that period. In the Polytechnics, students' participation in mathematics modules will depend on the course requirements. A detailed breakdown of student enrolment in each course within each field of study is not available so the students' participation rates in mathematics modules within each field of study reported in Table 3 are only estimates[30]. About 78% of the students enrolled in courses with at least

[25] http://www.highsch.nus.edu.sg/content.php?id=3295c76acbf4caaed33c36b1b5fc2cb1
[26] Calculated from statistics within Education Statistics Digest 2011: http://www.moe.gov.sg/education/education-statistics-digest/files/esd-2011.pdf
[27] Hodgen, J., Pepper, D., Sturman, L. & Ruddock, G. (2010). *Is the UK an outlier? An International Comparison of Upper Secondary Mathematics Education*. Nuffield Foundation.
[28] This percentage will be an underestimate for mathematics participation rate in pre-university education since it excludes students in IB programme and NUS High School. Mathematics is compulsory for students in IB programme and the NUS High School.
[29] Calculated from statistics within Education Statistics Digest 2011: http://www.moe.gov.sg/education/education-statistics-digest/files/esd-2011.pdf
[30] The course listings in the Polytechnics' prospectus were examined to identify courses with at least one mathematics or mathematically related module as a compulsory module. The figures in Table 2 are estimated based on the following: (1) Proportion of courses within each field of study with at least one of these subjects as a course requirement - Mathematics, statistics, quantitative research methods, quantitative analysis or accounting (P_1), (2) Estimate the number of students in each field of study who are required to take mathematics or its related modules by P_1 multiplied by its intake.

one of the following modules: mathematics at different levels, Statistics, Quantitative Research Methods, Quantitative Analysis or Accounting.

Table 2: Polytechnics Intake

Field of Study	**Intake (%)**		
	2008	**2009**	**2010**
Applied Arts	1646 (6.6)	1690 (6.6)	1939 (7.5)
Architecture & Building	623 (2.5)	545 (2.1)	603 (2.3)
Business & Administration	5827 (23.4)	5715 (22.3)	5707 (2.2)
Education	194 (0.8)	206 (0.8)	271 (1.1)
Engineering Sciences	7452 (30.0)	7775 (30.3)	7555 (29.4)
Health Sciences	2363 (9.5)	2539 (9.9)	2655 (10.3)
Humanities & Social Sciences	479 (1.9)	535 (2.1)	683 (2.7)
Information Technology	3943 (15.9)	4026 (15.7)	3687 (14.3)
Legal Studies	128 (0.5)	129 (0.5)	143 (0.6)
Mass Communication & Information Science	542 (2.2)	685 (2.7)	664 (2.6)
Science & Related Technologies	1354 (5.4)	1503 (5.9)	1534 (6.0)
Service	287 (1.2)	276 (1.1)	266 (1.0)
Total	24838 (100)	25624 (100)	25707 (100)

Table 3: Estimated Students' Participation in Mathematics or its Related Modules

Field of Study	Intake (%)		
	2008	**2009**	**2010**
Applied Arts	380 (1.9)	390 (1.9)	450 (2.3)
Architecture & Building	160 (0.8)	140 (0.7)	150 (0.8)
Business & Administration	5300 (27.1)	5200 (25.8)	5190 (26.1)
Education	60 (0.3)	70 (0.3)	9 (0.0)
Engineering Sciences	7452 (38.1)	7775 (38.6)	7555 (38.0)
Health Sciences	1580 (8.1)	1690 (8.4)	1770 (8.9)
Humanities & Social Sciences	320 (1.6)	360 (1.8)	460 (2.3)
Information Technology	2630 (13.4)	2684 (13.3)	2458 (12.4)
Legal Studies	128 (0.7)	129 (0.6)	143 (0.7)
Mass Communication & Information Science	0 (0)	0 (0)	0 (0)
Science & Related Technologies	1270 (6.5)	1410 (7.0)	1440 (7.2)
Service	287 (1.5)	276 (1.4)	266 (1.3)
Total	19567 (100)	20124 (100)	19891 (100)

About 21%[4] of the Primary 1 cohort was admitted into ITE from 2008 to 2010. Table 4 shows the ITE intake during that period. As in the case of the Polytechnic data, a detailed breakdown of student enrolment in each course within each field of study in the ITE is not available and the numbers reported in Table 5 are only estimates[31]. About 20% of the students in ITE would have studied at least one module in Mathematics, Statistics or Accounting (MSA).

[31] Estimates are based on the same procedure used to obtain the estimates in the Polytechnics.

Table 4: ITE Intake

Field of Study	Intake (%)		
	2008	**2009**	**2010**
Applied and Health Sciences	1174 (8.2)	1156 (8.4)	1138 (8.2)
Business & Services	4107 (28.9)	4076 (29.7)	4098 (29.5)
Engineering	4540 (32.0)	4121 (30.1)	4147 (29.9)
Info-Communications Technology	4261 (30.0)	3811 (27.8)	3892 (28.0)
Technical Skills	123 (0.9)	-	-
Design & Media	-	541 (3.9)	611 (4.4)
Total	14205 (100)	13705 (100)	13886 (100)

Table 5: Estimated Students' Participation in MSA

Field of Study	Intake		
	2008	**2009**	**2010**
Applied and Health Sciences	210 (6.8)	210 (7.4)	210 (7.3)
Business & Services	560 (18.2)	560 (19.6)	560 (19.5)
Engineering	1660 (54.0)	1510 (52.9)	1520* (52.9)
Info-Communications Technology	640 (20.8)	570 (20.0)	580 (21.2)
Technical Skills	0 (0)	-	-
Design & Media	-	0 (0)	0 (0)
Total	3070 (100)	2850 (100)	2870 (100)

*Nitec Engineering courses do not require mathematics as a core module.

Only a small proportion of the Primary 1 cohort was admitted into LASALLE and NAFA. All the courses in these two institutions do not required mathematics or its related modules as compulsory modules except for courses in the field of Business and Administration. Table 6 shows the intake in LASALLE and NAFA from 2008 to 2010.

Table 6: LASALLE and NAFA Intake

Field of Study	Intake (%)		
	2008	**2009**	**2010**
Business & Administration	128 (8.1)	134 (8.5)	148 (9.1)
Design & Applied Arts	658 (41.6)	603 (38.1)	608 (37.3)
Fine & Applied Arts	492 (31.1)	449 (28.4)	495 (30.3)
Fine & Performing Arts	264 (16.7)	306 (19.3)	351 (21.5)
Media Production	27 (1.7)	32 (2.0)	28 (1.7)
Others	11 (0.7)	-	-
Total	1580 (100)	1580 (100)	1630 (100)

Based on the above figures, an estimated 66%[32] of students in Post-secondary education, 61% of the age cohort, are enrolled in some mathematics courses, whilst an estimated 39%[33] of students in Post-secondary education, 36% of the age cohort, are enrolled on advanced mathematics courses.

3. What are the patterns of participation in terms of following different routes involving mathematics?

→ What are current levels of participation in different mathematics options amongst the upper secondary cohort and age group?

See Section 2.

4. What is the content and level of the different kinds of provision?

→ What is the structure and content of the mathematics options?
→ How is teacher education organised in order to offer the mathematics options?

Pre-University ('A' Level)

Mathematics at 'A' Level is offered at three different levels: H1, H2 and H3. H1 and H2 mathematics are assessed in GCE 'A' Level Examination. H3 mathematics is offered in three different modes:

i. Taught course with a prescribed syllabus provided by the Singapore Examinations and Assessment Board (SEAB)

[32] Estimated percentage of Primary 1 cohort with mathematics course(s) in Post-secondary education = estimated figures in pre-university + polytechnics + ITE + LASALLE/NAFA. This figure probably underestimates the mathematics participation rate among the Post-secondary students since the 80% participation rate in pre-university education exclude those in IB programme and the NUS High School and the estimated figures in this section exclude those courses with mathematics or its related modules as electives.

[33] Using the proportion of Engineering students as an estimate for all students in the polytechnics and adding to the proportion taking advanced mathematics in JC. This assumes that no students in ITE and LASALLE/NAFA take advanced mathematics.

ii. Taught course by local universities
iii. Advanced content research project

The first mode is assessed in the GCE 'A' Level Examination.

H1 syllabus[34] covers the following content areas:

i. Pure Mathematics
   a. Functions and Graphs
   b. Calculus
ii. Statistics
   a. Probability
   b. Binomial and Normal Distribution
   c. Sampling and Hypothesis Testing
   d. Correlation and Regression

In the GCE 'A' Level Examination, students sit a three-hour paper with five questions of different lengths and marks based on the Pure Mathematics content and six to eight questions based on the Statistics content. Pure Mathematics covers 37% and Statistics 63% of the paper.

The H2 syllabus[35] covers the following areas:

i. Pure Mathematics
   a. Functions and Graphs
   b. Sequences and Series
   c. Vectors
   d. Complex Numbers
   e. Calculus
ii. Statistics
   a. Permutation, Combinations and Probability
   b. Binomial, Poisson, and Normal Distribution
   c. Sampling and Hypothesis Testing
   d. Correlation and Regression

Compared to the H1 syllabus, the Pure Mathematics content in the H2 syllabus not only includes more topics (e.g. Vectors and Complex Numbers), but for similar topics such as Calculus, the H2 content extends beyond the H1 syllabus to covers more integration techniques, definite integrals and differential equations. For Statistics, the content coverage in H2 and H1 are more similar with H2 content covered slightly more than that in the H1. In the GCE 'A' Level Examination, students are assessed based on two three-hour papers each carrying 50% of the total marks. Paper 1 consists of 10 to 12 questions of different lengths and marks based on the Pure Mathematics content while Paper 2 consists of three to four questions on the Pure Mathematics content and six to eight questions on the

[34] http://seab.gov.sg/aLevel/2013Syllabus/8864_2013.pdf
[35] http://seab.gov.sg/aLevel/2013Syllabus/9740_2013.pdf

Statistics content. Overall, in H2 mathematics, Pure Mathematics covers 70% while Statistics covers 30% in the 'A' Level Examination.

The content[36] of H3 mathematics in the 2013 GCE 'A' Level will comprise three topics in H2 (Functions and Graphs, Sequences and Series, and Calculus) and two additional topics, Combinatorics and Differential Equations as Mathematical Models. The demand of topics covered in the H3 syllabus is pitched at a higher level of difficulty. Students taking the H3 GCE 'A' Level mathematics are assessed based on a three-hour paper with eight questions of different lengths and marks. The total weights of content covered in the H2 syllabus is approximately 40%, Combinatorics is 25% and Differential Equations as Mathematical Models is 35%. Students taking H1, H2 or H3 are expected to answer all the questions in the GCE 'A' mathematics examinations.

H3 mathematics in form of a university taught course is offered by two local universities. Numbers & Matrices is offered by Nanyang Technological University and Linear Algebra is offered by National University of Singapore. This arrangement is made between the universities and the Ministry of Education. University lecturers teach these courses either in hosting schools or students would travel to the university to attend classes. Numbers & Matrices is assessed based on two one-hour written papers (30%) and one two-hour written paper (70%). Students taking Linear Algebra are assessed based on mid-term, final term tests and a Computer Lab quiz.

The third mode of H3 mathematics takes the form of advanced content research projects. A project must be endorsed by the student's school and a project supervisor. A student taking this option undertakes research activities supervised by a university faculty member and is required to submit a research paper and a poster presentation.

<u>Pre-university (IB)</u>

There are four mathematics options (Mathematics Studies at Standard Level (SL), Mathematics at SL or Higher Level (HL), and Further Mathematics at SL) in the IB programme to cater to students with different abilities and interests.

Content covered in Mathematics Studies[37] are:

i. Introduction to the Graphic Display Calculator
ii. Number and Algebra
iii. Sets, Logic and Probability
iv. Functions, Geometry and Trigonometry
v. Statistics
vi. Introductory Differential Calculus
vii. Financial Mathematics

Content covered in Mathematics (SL)[38] are:

[36] http://seab.gov.sg/aLevel/2013Syllabus/9824_2013.pdf
[37] http://sites.acsindep.edu.sg/mathematics/sow/math%20studies%20sl%20guide.pdf

i. Algebra
ii. Functions and Equations
iii. Circular Functions and Trigonometry
iv. Matrices
v. Vectors
vi. Statistics and Probability
vii. Calculus

Mathematics (HL)[39] content covers the same topics as in Mathematics (SL) but with more depth. In addition, students are required to select one of the four content areas: Statistics and Probability, Sets, Relations and Groups, Series and Differential Equations, and Discrete Mathematics. Further Mathematics[40] consists of one geometry topic and the four optional topics listed in Mathematics (HL).

Assessment in Mathematical Studies (SL), Mathematics (SL), and Mathematics (HL) comprises 80% external assessment and 20% internal assessment. For Further Mathematics, 100% of the assessment is external. External assessment of Mathematical Studies consists of two 90-minute papers of equal weight and internal assessment based on a student project. External assessment of Mathematics (SL) is based on two 90-minute written and internal assessment is made up of two pieces of work (mathematical investigation and modeling) assigned by the teacher. External assessment of Mathematics (HL) is based on three written assessments, two two-hour papers and one one-hour paper and the internal assessment is based on portfolio of two pieces of work as in Mathematics (SL). The internal assessment in the IB programme is carried out by the teachers and moderated by the IB office. Further Mathematics is assessed based on a one-hour and a two-hour written paper. Students have to answer all questions in the external assessment.

NUS High School

In the NUS High School, the curriculum[41] is divided into Foundation Years (Year 1 & 2), Advancement Years (Year 3 & 4) and Specialisation Years (Year 5 &6). In the Foundation Years, students are given broad-based exposure to Algebra, Geometry, Statistics and Trigonometry. In the Advancement Years, the syllabus covers pre-calculus topics such as Functions, Trigonometry, Sequences and Series, introduction to Vectors, Numerical Methods and Calculus. In the Specialisation Years, students are given opportunities to study more Calculus, Statistics and Pure Mathematics. In addition, there are three different Advanced Placement mathematics syllabus options, two in Calculus and one in Statistics. Assessment components in NUS High include both continual and semestral components.

Polytechnics & ITE

A range of mathematics courses is offered in the Polytechnics. Courses in Engineering

[38] http://sites.acsindep.edu.sg/mathematics/sow/IBO%20SL%20Mathematics%20Guide.pdf
[39] http://sites.acsindep.edu.sg/mathematics/sow/math%20hl%20guide.pdf
[40] http://sites.acsindep.edu.sg/mathematics/sow/IBDP%20Further%20Mathematics%20SL%20Syllabus.pdf
[41] http://www.highsch.nus.edu.sg/userfiles/file/Programme%20Of%20Studies%202012/Programme%20of%20Studies%202012%20_Public%20Version_12.01.06.pdf

Sciences, Health Sciences and Sciences & Related Technologies have mathematics modules in Statistics and Calculus as core, and Advanced Calculus as elective. Statistics and Accounting are compulsory modules in many of the courses in Business and Administration. Courses in Humanities & Social courses have Statistics and Quantitative Research Methods modules as core modules.

As in the Polytechnics, a range of mathematics courses is offered in the ITE, some are core and some are electives. For example, Higher Nitec courses in Engineering have Engineering Mathematics as compulsory modules and Calculus as electives, while Nitec courses in Engineering have Technical Mathematics, Mathematics (Level 9 and 10) and Mathematics 'O' (I, II, III, IV) as electives. Content in Mathematics (Level 9 and 10) includes arithmetic calculations, interpret and use statistical data, manipulate algebraic expressions, use graphs and solve simultaneous equations graphically, simple geometry, and trigonometry. Content in Mathematics 'O'' (I, II III & IV) is similar to the GCE 'O' Level Mathematics. Assessment components in the Polytechnics and ITE are institution-based.

Teacher Recruitment and Professional Development

Teachers teaching Primary 1 to Pre-university level are recruited and employed by the MOE and trained by the sole provider of pre-service teacher education, the National Institute of Education (NIE). Mathematics teachers at the Pre-university level undergo a 1-year Postgraduate Diploma in Education (Secondary) programme in the NIE. With effect from 2009, the Postgraduate Diploma in Education (JC) was introduced to better tailor to the needs of teachers in the JCs and Centralised Institute. In the Postgraduate Diploma course, pre-service teachers are attached to a school to complete a 10-week practicum.

Upon completion of training in the NIE, teachers are posted by the MOE to different schools. However, independent schools (e.g. Hwa Chong Institution) and specialised independent schools (e.g. NUS High School) can employ their own teaching staff and teachers with experience teaching in government and government-aided schools can apply to these schools or could be posted to these schools under the MOE secondment scheme. Specialised Independent schools do employ teachers without teaching qualification but this will only constitute a very small percentage, as generally principals do value the importance of pedagogy training.

There are many in-service training opportunities for teachers and teachers are entitled to 100 hours of professional development each year. The MOE also offers scholarships, study leave and study loans for outstanding teachers who wish to pursue Masters and PhD level postgraduate study. In 2012, the MOE launched the Teacher Growth Model[42] (TGM), a professional development model developed by the Academy of Singapore Teachers. TGM focuses on teachers taking ownership of their own professional development to engage in continual learning. There are five main pillars in TGM:

[42] http://www.moe.gov.sg/media/speeches/2012/05/31/address-by-mr-heng-swee-keat-a.php

i. *Shift from deficit model to growth* by building strengths and interest
ii. *Greater Teacher Autonomy and Ownership* – teachers to chart their professional development
iii. *Application of Learning to Close the Gap between Theory and Practice* with greater emphasis on sustained learning, application and reflection
iv. Mentoring and Teacher Collaboration
v. Global Understanding grounded in Local Perspectives and Contexts

The Ministry offers three career tracks for teachers: Teaching, Specialist and Leadership. The three career tracks aim to nurture and motivate teachers to achieve superior performance and to advance their career in different areas.

ITE recruits its own staff and provides the in-house Pedagogical Certificate in Technical Education (PCTE) course for all teachers teaching Technical or Business Studies courses. Staff are also entitled to 100 hours professional development per year. Other professional development opportunities include full sponsorship for formal training programmes, half-pay leave for full-time training programmes, full-pay sabbatical leave for staff to attach to other institutions for research or attendance at conferences, and industry attachment. Similarly, the Polytechnics and the arts institutions employ their own staff and provide multiple professional development opportunities for their staff.

5. How are the different mathematics options assessed?

→ How and when are students assessed for summative purposes?
→ Are any alternative assessment pathways available?

See section 4 for the high-stakes examinations for students in different pre-University courses.

A final year examination is conducted at the end of the first year for students in JCs (for students in Centralised Institute, final year examinations are conducted at the end of the first and second year). Continual assessments are used together with the final examination to promote students to the next year. Prior to the culminating examination in the second year for a student in the JC (or third year in the Centralised Institute), each school administers a preliminary examination which adopts the same structure as the culminating examination to provide students with the experience of the actual examination. Students who do not perform well in the preliminary examination are provided with remedial lessons and consultation sessions with tutors to help them better prepare for the culminating examination.

At pre-university education, teachers have attempted to explore alternative assessments such as open-ended tasks, journal writing, and student portfolios. These assessments mainly form part of the continual assessments. However, there is no concrete evidence of the use of alternative assessments on a large scale in the pre-University institutions. Many of the teachers are still faced with the problem of a very heavy content within a short curriculum time.

Courses in the ITE and Polytechnics are modular in nature. At the end of each module, students are required to pass the final examination. Continual assessments are used together with the final examination to gauge whether a student has met the criteria of the course.

6. What information is available on students' learning outcomes in secondary education?

→ What research or policy evidence is available on students' expectations, attitudes and attainment in relation to mathematics in lower and upper secondary education?

Singapore has repeatedly excelled in the Trends in International Mathematics and Science Study (TIMSS). Among the participating countries, Secondary 2 students in Singapore were ranked top and third in 2003 and 2007. In PISA 2009, the mean score of Singapore students in mathematics was significantly higher than most other participating countries. Singapore also had the second highest proportion of top performers in mathematics.

In TIMSS 2007 student attitudinal questionnaire results[43], 60% and 20% of Singapore Secondary 2 students reported high and medium positive affect towards mathematics respectively compared to the international average of 54% and 10% respectively. Also, 77% of Singapore students placed high value on mathematics and 19% placed medium value on mathematics and these percentages were comparable to the international average of 78% and 17% respectively. However, in terms of students' confidence in doing mathematics, only 41% reported that they have high self-confidence compared to the international average of 43%. Similar results were reported by Fan et al. (2005)[44]. In their survey involving Secondary 1 students in Singapore, Fan et. al reported that students believe that *mathematics is useful* (91%), *important* (89%), and *learning mathematics is not wasting their time* (84%). They also reported that students generally feel that *mathematics is interesting to them* (73%) and *students enjoy doing mathematics* (74%). However, they also reported that only 64% of students think that *they will use mathematics a lot as adult*, only 63% of students *like to attend Mathematics lessons*, 49% of students *like spending time on studying mathematics*, and 37 % of students thought that *mathematics is hard for them*. They also found more than 30% of students *have the feeling of being stressed when they attend mathematics lessons*.

7. What vocational education options are available at upper secondary level?

→ What is the structure and content of the vocational courses available?
→ What status do vocational courses have in comparison to other options?
→ What are the participation levels in these courses?
→ How much mathematics is included in vocational education courses and at what levels?

[43] Mullis, I. V. S., Martin, M. O., Foy, P., Olson, J. F., Preuschoff, C., Erberber, E., Galia, J. (2008). *TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades.* Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.
[44] Fan, L., K. S. Quek, et al. (2005). Assessing Singapore students' attitudes toward mathematics and mathematics learning: Findings from a survey of lower secondary students. *ICMI Regional Conference: The 3rd East Asia Regional Conference on Mathematics Education*, Shanghai, Nanjing, and Hangzhou, China, 2005.

Secondary education in Singapore provides students with a broad-based education which aims to prepare students for various pathways and specialisation at the post-secondary / upper-secondary level. Vocational courses in Singapore typically begin at post-secondary and are offered by the ITE and Polytechnics. However, since 2006, secondary schools have introduced elective modules together with post-secondary educational institutions or external agencies to develop NA and NT students' interests and strengths in specific vocational areas. Two new specialised secondary schools for NT students will also start admission from 2013 to provide NT students with *industry-focused* modules in addition to the current NT subjects. These two schools will have a higher teacher-to-student ratio to better support the teaching of *industry-focused* modules.

The ITE[45] offers four certification levels – Nitec, Higher Nitec, Master Nitec and Technical Diploma. The first two certification levels are for secondary school leavers. Nitec training courses require completion of GCE 'N' or 'O' as an entry requirement with pre-requisites for certain courses while Higher Nitec training courses require GCE 'NA' or 'O' with pre-requisites as an entry requirement, i.e. the entry requirements for Higher Nitec courses are higher compared to those for Nitec courses. A course of study in ITE is made up of a series of modules and there are four different types of modules – core, specialisation, life skills and elective. Students must pass all core modules and take specialisation modules in their courses in order to obtain full certification. Life skills modules focus on personal competence which an individual can transfer from one job to another while elective modules provide students with more breadth and depth in their field of study. Mathematics modules (e.g. Technical Mathematics, Mathematics 'O') in Nitec courses are offered as elective modules. In Higher Nitec, some mathematics modules are core and some are electives in a course (e.g. Engineering Mathematics is a core module and Calculus is an elective module in Process Plant Design); statistics is offered as an elective module and accounting is offered as a core in some of the courses in Business and Services.

The Polytechnics offers *practice-oriented* training to equip their graduates with skills and knowledge as middle-level professionals. The Polytechnics offer a range of courses at Diploma level in different areas as mentioned previously. Diploma courses require GCE 'O' level as an entry requirement. Starting in 2013, Polytechnics will also admit NA students with good results in the GCE 'N' Level examination (top 10%). These students will be provided with a 1-year preparatory foundation course for students prior to the 3-year Diploma programme. The next 20% of the students can opt for ITE Direct Entry Scheme and students in this scheme with qualifying GPA in ITE will be given a place in a related Polytechnic course. For NA students who qualify and continue with the GCE 'O' Level in their fifth secondary year mathematics remains a compulsory subject as is the case for all Express students taking GCE 'O' Level.

[45] http://www.ite.edu.sg/admission/ft/GeneralInformation.pdf

8. What drives the pattern of take-up? How is it linked to the needs of HE, employers and national policy objectives?

- → What are the official criteria, if any, for acceptance to the mathematics options?
- → Are there any unofficial / local criteria for acceptance to the mathematics options?
- → What information, advice or guidance is there about the mathematics options?
- → Are any mathematics recruitment policies targeted to specific groups or types of students?
- → Which subjects and options are students expected or required students to take?
- → Please note the views of, for example, further/higher education institutions, employers, parents or the public more generally
- → Are there 'unofficial' expectations to have particular mathematics qualifications for entry to particular HE courses?

Admission to JCs and Polytechnics can be via direct admission exercises[46] or based on applicants' national examination results. The direct admission exercises provide JCs and Polytechnics with more flexibility to select students and students with an opportunity to demonstrate a more diverse range of achievements and talents in seeking admission at the Post-secondary level. In the direct school admission-JC (DSA-JC) exercise, participating JCs admit students using their own merit-based criteria, which include both academic and/or non-academic criteria, with a focus on their niche areas. To ensure that students are able to cope with the rigour of the pre-university curriculum, students admitted via the DSA-JC exercise must meet the prevailing JC admission eligibility criteria (see below). In the direct Polytechnic admission (DPA) exercise, Polytechnics will take into account students' abilities, talents and interests in the specific courses that they have applied for. To ensure that students admitted through DPA are able to cope with the rigour of a polytechnic education, applicants must also meet the prevailing Polytechnic admission criteria (see below) and the minimum entry requirements for the respective course.

In DSA-JC, government or government-aided JCs can admit up to 10% of their student intake using school-based criteria while the independent institutions offering pre-university courses can admit up to 20% of their intake using their school-based criteria.[47] The Polytechnics can admit up to 2.5% of their intake and a course-specific cap of 30% through DPA[48]. According to the Ministry, these quotas ensure that students admitted through the national examination route will continue to have access to these institutions.

Students applying to JC with their GCE 'O' Level Examination results must satisfying the minimum requirement of L1R5 aggregate point[49] of not more than 20 with a pass in English Language, at least a D7 in Mathematics/Additional Mathematics, and a minimum proficiency in Mother Tongue Language. L1R5 refers to First Language and five relevant subjects. A student's First Language can be English Language or Higher Mother Tongue. For the five relevant subjects, one must be taken from Humanities, one from Mathematics or Science,

[46] http://www.moe.gov.sg/media/press/2010/05/direct-admission-exercises-for-jcs-polytechnics.php
[47] http://www.moe.gov.sg/media/press/2010/05/direct-admission-exercises-for-jcs-polytechnics.php
[48] http://www.moe.gov.sg/education/admissions/dpa/criteria/
[49] Grading system in GCE 'O' Level: A1, A2, B3, B4, C5 and C6 are passing grades. D7 and E8 are borderline fail and F9 is a failed grade.

one from Mathematics, Science or Humanities, and the other two subjects can be any other 'O' Level subjects except Religious Knowledge and Co-curricular Activities (CCAs). Admission to the JCs is based on merits according to students' aggregate points taking into consideration bonus points of students. Up to 2 bonus points are given for students' CCA involvement; 2 bonus points each for students who have obtained a pass grade for Higher Mother Tongue and Third Language; and 2 bonus points for students from affiliated secondary schools. There is a cap of 4 bonus points and for students who are applying to Chinese/Malay Language Elective Programme at JC, an additional 2 bonus points are awarded. To illustrate, a student applying to a JC offering Chinese Language Elective Programme with 1 bonus points from his CCAs involvement and a pass grade in Higher Chinese Language will have 5 points deducted from his/her L1R5 aggregate point. Application to JCs is highly competitive and the cut-off L1R5 aggregate with bonus points for some JC can go as low as 3 points[50]. The average cut-off aggregate with bonus points for the Arts course at JC was 10.5 and that for the Science course was 9.8 in 2011.[51] Applicants to the Centralised Institute must have a L1R4 aggregate of not more than 20 points with the similar requirements for English Language, Mathematics/Additional Mathematics, and Mother Tongue Language as for JC applicants, i.e. admission criteria to Centralised Institute are less stringent compared to those for the JC. The bonus points system is also applicable to students applying to Centralised Institute.

Knowledge of the content of the GCE 'O' Level mathematics syllabus is assumed for H1 mathematics. For H2 mathematics, in addition to the 'O' Level mathematics syllabus, some of the content of the GCE 'O' Level Additional Mathematics syllabus is assumed. Hence only a very small percentage of students offering H2 Mathematics do not have Additional Mathematics at the secondary level. H2 mathematics is a pre-requisite for offering H3 mathematics.

Admission to Polytechnics with GCE'O' Level results is based on ELR2B2 aggregate points - English Language, two relevant subjects for the Polytechnic course applied for, and two other subjects. Only CCAs bonus points are included in the computation of the net aggregate point, i.e. a maximum of two bonus points for Polytechnic applicants. To be eligible for admission to a course in a polytechnic, an applicant must have a net ELR2B2 of 26 points or less and satisfy the minimum criteria for English Language, Mathematics, and any other relevant subjects applicable to the course. In some courses, the minimum requirement for Mathematics is a D7 and in some courses, the minimum requirement is a pass. Some of the Polytechnic courses are highly sought by secondary graduates and the cut-off net aggregate points of some course are below 10 points.[52] Compared to the Polytechnics, admission to ITE is less stringent. No minimum requirement is set for aggregate points but each course in the ITE has its minimum entry requirements for English Language and Mathematics as well as relevant subjects if applicable. Admission into a course of students' choice is based on merit of their aggregate points.

[50] http://www.moe.gov.sg/education/admissions/jae/files/jae-info.pdf
[51] http://www.moe.gov.sg/media/press/2010/05/direct-admission-exercises-for-jcs-polytechnics.php
[52] E.g., the cut-off net aggregate for Biomedical Science in Singapore Polytechnic was 8 and Banking and Financial Services in Ngee Ann Polytechnic was 9 in 2011.

There are four publicly-funded universities (National University of Singapore, Nanyang Technological University, Singapore Management University and Singapore University of Technology & Design) and 26%[53] of Primary One cohort matriculates into publicly-funded full-time undergraduate programmes. The government plans to increase this percentage to 30% by 2015 and in the Report of the Committee on University Education Pathways Beyond 2015[54] (CUEP), the committee recommended that the publicly-funded pre-employment university cohort participation rate be increased to 40% by 2020. The report highlighted that 46% of the *economically-active* 25- to 29-year old Singaporean residents in 2011 held degree qualifications and the labour market in Singapore is able to support a workforce where over 40% of the cohort have degrees. In addition, the report also recommended that publicly-funded continuing education and training (CET[55]) degree places could be increased to 10% (an increase from the current estimated 7%) by 2020.

Applicants to the publicly-funded universities must satisfy the minimum application criteria of at least two H2 passes, an attempt at General Paper or Knowledge & Inquiry in the same sitting, and an attempt at Mother Tongue Language (MTL). Applicants are selected based on their grades in three H2 and one H1 content-based subjects with at least one has to be a contrasting subject, General Paper (or Knowledge & Inquiry) and Project Work. MTL grade may be submitted for consideration. Applicants must also satisfy minimum MTL proficiency level[56]. Students' co-curricular activities will be considered qualitatively. Though mathematics is not a required subject for university application, a pass in Additional Mathematics at the GCE 'O' Level or H1 mathematics at the GCE 'A' is a pre-requisite to gain admission to some of the non-science/mathematics related courses (e.g. Business courses) in the local universities. An average of 75%[57] of the students who sat for the GCE 'A' Level examinations were admitted into publicly funded university places. Applicants with the IB Diploma and NUS High School Diploma are selected based on their IB score and grades in relevant subjects depending on the faculty which they apply to[58]. Polytechnic graduates who perform well may pursue degree courses at these universities. About 45% of polytechnic graduates from the 2005 cohort had successfully completed a degree qualification within five years of their graduation from the polytechnic.[59] Singapore Institute of Technology (SIT) was established in 2009 to offer degree programmes in partnerships with overseas universities to provide upgrading opportunities primarily for Polytechnic graduates. In 2011, SIT also accepted a limited number of applications with other qualifications such as the GCE 'A' Level and IB. The CUEP recommended that SIT be developed into Singapore's

[53] http://www.moe.gov.sg/feedback/2011/committee-on-university-education-pathways-beyond-2015/singapore-university-landscape/
[54] http://www.moe.gov.sg/media/press/files/2012/08/cuep-report-greater-diversity-more-opportunities.pdf
[55] In 2008, the National CET Masterplan was launched by the Ministry of Manpower and Workforce Development Agency to increase the national CET. MOE started to subsidise fee for part-time undergraduate at the publicly-funded universities and SIM University (UniSIM) in 2008. UniSIM is a private university in Singapore.
[56] At least a D7 in GCE 'O' Level Higher MTL or a 'S' grade in H1 MTL or a pass in MTL 'B'.
[57] Report of the Committee on University Education Pathways Beyond 2015 (CUEP)
[58] http://www3.ntu.edu.sg/CorpComms2/releases/16%20May%202005%20Univ%20Adm%20Fwk%20under%20new%20A-level%20curriculum%20(Annex%20D).pdf
[59] http://www.moe.gov.sg/media/press/files/2012/08/cuep-report-greater-diversity-more-opportunities.pdf

5th autonomous university which has an *applied degree pathway*. ITE graduates who perform well may apply to related courses in the Polytechnics.

The MOE launched the Education and Career Portal in 2009 to support teachers and counsellors to guide students in their education and career choice. The portal has profiling instruments to help students identify their interests and aptitudes and guides students on careers and courses choices in post-secondary institutions.

9. What policies and practices are there for transition and retention?

→ What policies or practices are there to support students' transition from lower secondary to upper secondary mathematics options?
→ More generally, what policies or practices are directed at students struggling with upper secondary mathematics?

To ensure that higher education opportunities remain accessible to all, education at post-secondary level is heavily subsidised and there are various financial assistance schemes for needy students[60].

The Report of the Secondary Education Review and Implementation (SERI) Committee[61] recommends that the MOE facilitates the production of better instructional materials with commercial publishers for teaching mathematics to better support teachers in delivering the intended learners' outcomes of the mathematics syllabus. SERI also recommends additional allied educators (AEDs[62]) for mathematics and schools may deploy AEDs to support teachers teaching NA and NT courses.

In pre-university institutions, teachers are required to provide consultancy and remedial classes to help students who are struggling with their academic work.

10. What information is available on (other) factors affecting recruitment and retention?

→ What factors would you attribute to the upper secondary mathematics recruitment levels in your education system?
→ Please give details of any supporting information or sources

At the pre-university level, a broader curriculum has been implemented since 2006 requiring all students to offer both Arts/Humanities and Mathematics/Science in addition to the compulsory subjects: General Paper or Knowledge & Inquiry, Project Work and Mother Tongue Language. In the old framework, 40% of the JC students offered mathematics and science subjects, with no humanities offered beyond their 'O' levels. With the requirement of a contrasting subject, all science students not taking KI will need to include a subject in the

[60] http://www.moe.gov.sg/education/post-secondary/files/post-secondary-brochure.pdf
[61] http://www.moe.gov.sg/media/press/files/2010/12/report-secondary-education-review-and-implementation-committee.pdf
[62] AEDs work with teachers within and outside of classrooms to provide a quality learning experience for students.

Arts, Humanities, Language or Literature and vice versa. Likewise, Arts/Humanities students would need to take a science subject (mathematics and science) in their course. A natural choice for these students would be mathematics (instead of the other science subjects). Thus, with this new policy, more students might be taking mathematics as one of their subjects (at least H1 mathematics).

Before 2006, science students in pre-university education could take up to two GCE 'A' Level mathematics subjects: Mathematics C and Further Mathematics. 15%[63] of the 'A' Level cohort offered Mathematics C and Further Mathematics in the old 'A' Level. Students with aptitude and passion in mathematics could also offer the Special Paper in these two subjects. However, in the current GCE 'A' Level, students take one mathematics course at H1 or H2 level. Further Mathematics is no longer offered as an 'A' Level subject. H3 mathematics in the new 'A' Level replaces the Special Paper in the old 'A' Level and it must be taken together with H2 mathematics. This may suggest that the proportion of students doing more mathematics has dropped in the new 'A' Level.

Ability-driven education has been a key feature in the Singapore education system. Since its introduction in the late 1970s, it has gone through various refinements over the years to provide students with customised and differentiated learning experiences. About 60% of the secondary students are enrolled in Express, 25% in NA and 15% in NT. Students can move from one course to another based on their academic performance. There are also opportunities for NA and NT students to take selective subjects at a more advanced level. For example, since 2004, NA students with ability and interest in mathematics can offer Additional Mathematics in addition to Elementary Mathematics. According to the Ministry, the different streams cater to students with different abilities and interests, help more students to stay engaged in their learning and have brought the drop-out rates down.

[63] Shanmugaratnam, T. (2002). *Report of the Junior College / Upper Secondary Education Review Committee.* Singapore, Ministry of Education.