MATHEMATICS EDUCATION REFORM IN HONG KONG

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Abstract. This paper presents an overview of mathematics education in Hong Kong and the education reform it is experiencing. The original mathematics curricula had been successful in certain ways (as demonstrated by the achievements of Hong Kong students who placed fourth in TIMSS); however, there were also negative aspects. The revision in both primary and secondary mathematics education aims to shift the emphasis to the development of thinking abilities and positive attitudes of students towards learning the subject. Mathematics is expected to provide a basis for making investigations as well as a tool for analyzing data, representing findings, and formulating theories. Teachers are encouraged to adopt a student-centered, activity-based, and hands-on approach to organize students' learning, and to make use of concrete examples from everyday life whenever possible. Student learning is expected to progress from concrete to abstract, and calculators and computers are expected to be used to facilitate student learning. Some implications of these approaches are also discussed.

1. Introduction: the Hong Kong education context

Traditionally, the Hong Kong education system has been examination-driven. Students undergo six years of primary and five years of secondary schooling, of which the first nine years are considered to be compulsory basic education. For students who wish to enter university, there would be two additional years of matriculation prior to university studies. At each transition, progression to the next phase is based on the results obtained by students in public examinations. Performances at public examinations would determine the band (level) of school assigned to the student at Secondary 1, whether the student is accepted for matriculation studies at the end of Secondary 5, and whether the student would have a place at a Hong Kong university after Secondary 7.

Currently, about 50% of S5 graduates can enter matriculation, which about 50% of the candidates do pass, but not all of the successful candidates can find places in university. For 2002, about 3500 students who pass matriculation will not be able to find places in Hong Kong universities. Under this system, only about 18-20% of secondary school graduates can enter university, which is considered to be the key to any professional career.

Under this atmosphere of examinations and strong competition, schools tended to consider the attainment of good examination results as their top priority. In order to achieve this objective, students have been exposed to constant drills on skills and content in order to hone their abilities in writing examinations.

Mathematics is a core subject in the Hong Kong school curriculum; primary school students would have mathematics classes every day, and this practice continues through secondary school. In fact, students cannot graduate from secondary school (at Secondary 5) without passing a public examination in mathematics. To ensure successful performance in this subject, Hong Kong students spent more out of school time doing mathematics homework, studying mathematics or attending extra mathematics lessons, especially at the primary level, than their counterparts in other countries (Mullis et al. 1997).

This examination-oriented approach has also resulted in Hong Kong being probably the place with the least flexibility and choice in its mathematics curriculum (CDC 2000), because teaching and learning must be focused on the public examination syllabus, and on students' proficiency to work out problems in this syllabus. Primary and junior secondary students seem to associate mathematics with its terminology and content, and doing mathematics is often perceived to be applying a set of rules rather than a thinking process (Lam et al. 1999). One result of these existing practices is that students and parents considered mathematics to be an important subject, and students performed extremely well (4th) in the TIMSS mathematics tests, but some of them did not display a corresponding positive attitude towards the subject (Mullis et al. 1997).

Another factor that has contributed to the problems of education in Hong Kong is that education, rightfully for an advanced society, has evolved from being a privilege to a right, with the provision of compulsory education up to S3 for all students. However, the curriculum has remained the rather elitist one of a former era, when education had not been designed for all. Consequently, learning has been difficult for many students, especially in a subject such as mathematics, which is often considered to be abstract and complex. To compound the problem, the Hong Kong mathematics curriculum has been found to be content-oriented, rather packed, and difficult (CDC 2000). A comparative study of the mathematics curricula of major Asian and western countries has found that in Hong Kong, the introduction of topics into the curriculum is on average two years earlier than the international average (CDC 2000).

2. Education reform

Concern over the entire education system has prompted the government to establish an Education Commission (EC) to conduct a comprehensive review of the system with a view to define the aims of education and a blueprint for reform for the 21st Century. At the same time, the government-funded Curriculum Development Council initiated a holistic review of the school curriculum in 1999, and a new curriculum framework together with syllabuses were to be introduced in primary and secondary schools in 2002 and 2001 respectively.

The new curriculum framework was designed based on the following main principles:

- Develop independent learning capabilities in students, or help students *learn to learn*, by developing their generic skills and interest
- Adopt a learner-focused approach that can cater to individual needs, learning styles, interests, and abilities
- The curriculum should be a broad and balanced one that employs diversified learning, teaching, and assessment strategies

The new mathematics curriculum was designed in accordance with these principles; for example, to develop students' abilities in inquiring, reasoning, conceptualizing, problem-solving, and communicating. Students are expected to learn mathematics to enhance these generic skills at the same time that they apply these skills to construct their knowledge of mathematics. Through the learning process, students should be able to establish confidence and positive attitudes towards mathematics, and to appreciate its beauty and its relation to various cultural aspects.

In order to accommodate the different needs of students, the contents of the primary and secondary curricula have been reduced by about 15% and 11% respectively, so that teachers and students have some space and freedom for individual explorations of certain topics. There is flexibility for teachers to adopt some enrichment topics to extend their students' horizons, in addition to a foundation part of the curriculum. The curriculum is organized with consideration for the cognitive development of students, student learning is expected to progress from the concrete to the abstract, and connections to everyday experience are to be used to support abstract discussions whenever possible. Mechanical drilling in mathematics learning is to be reduced.

Another emphasis in the new curriculum is the use of information technology tools as aids to teaching and learning. Calculators and computers are to be employed to support learning and teaching activities throughout the curriculum where appropriate, including for observing patterns/transformations, data analysis, simulation, and graphical presentation.

We will present below the curriculum contents and the emphases in learning and teaching of mathematics in the new curriculum. These will show that the new curriculum has been planned in great detail, and can provide a basis for comparison with curricula of other settings. For a more concentrated discussion, the focus will be on the important dimensions of number and algebra.

2. Primary mathematics

The dimensions of primary mathematics are Number (44%), Shape and Space (14%), Measures (18%), Algebra (3%), and Data Handling (6%). The percentages in the parentheses are the suggested time allocations for the teaching of each dimension, in addition to which are 13% of spare periods (out of a total of 960 mathematics periods for the six years). Obviously the most significant area is Number, in which the topics to be studied include the following:

Level	Contents	Learning Objectives
P1	Numbers to 100	Understanding of numbers through counting, reading and writing
	Addition and subtraction within two places	Basic concepts Understanding of Zero through subtraction Relationship between addition and subtraction Recognize commutative property of addition Solve simple problems and estimate answers
P2	3- digit numbers	Understanding of these numbers through counting, reading and writing
	4-digit numbers	Count in groups of five hundred and thousand Recognize place values 'hundreds' & 'thousands'
	Addition and subtraction within three places	Perform these operations, including decomposition in subtraction

		Perform mixed operations (up to 2 operations) Solve simple problems and estimate answers
P3	5-digit numbers Addition and subtraction Multiplication Division Mixed operations (addition, subtraction, multiplication and brackets) Fractions	Recognize place value 'ten thousands' Within four places 2- or 3-digit multiplicand, 1-digit multiplier Short division with 2- or 3-digit dividend, 1-digit divisor Recognize and use brackets in mixed operations Perform mixed operations of a. multiplication & addition b. multiplication & subtraction Solve problems (including calculation of money) and estimate answers Concept of fractions (part of a whole & part of a set) Recognize relationship between fractions & 1 Compare fractions with same denominator or numerator
P4	Multiplication Division Acquaintance with calculators Multiples and factors Common multiples and common factors Mixed operations Fractions Decimals	2- or 3-digit multiplicand, 2-digit multiplier Associative & commutative properties by examples 2- or 3-digit dividend, 2-digit divisor Recognize basic operations and functions Carry out activities to foster 'number sense' Understand concepts Find all factors of a number Explore relationship between factors and multiples Understand concepts Find common multiples (factors) and least (highest) common multiple (factor) from list of multiples (factors) of numbers All four operations, at most 4 steps Proper & improper fractions, mixed numbers Equivalent fractions and their conversions Add & subtract fractions with same denominator Basic concept & relation to fractions Concept of place value in decimals Use in everyday life
P5	Large numbers Fractions Decimals	Understand large numbers Concept of approximation and estimation Round off large numbers Add & subtract fractions - different denominators Multiplication & division of fractions Addition, subtraction (up to 2 places of decimals) Multiply decimals by whole numbers & decimals Multiplication in daily life examples; estimate answers.
P6	Decimals Percentages	Understand division of decimals through daily life examples Division by whole numbers and decimals Mixed operations on decimals Conversions between fractions and fractions Compare fractions by converting into decimals Daily life examples and understanding Convert between percentages and decimals/fractions Solve simple problems & estimate answers

Compared to the dimension of Number, Algebra occupies a very minor place in the primary curriculum, for the simple reason that algebra involves a certain level of abstraction which should be introduced at a later stage of development, in this case from P5 onwards.

Level	Topic	Learning Objectives
P5	Elementary algebra Simple equations	Use of algebraic symbols to represent numbers Understand the concept of equations Solve simple equations (only one step)
P6	Simple equations	Solve equations involving at most two steps Solve problems by simple equations (1 or 2 steps)

3. Secondary mathematics

In the secondary curriculum, Number and Algebra are merged into one dimension because, understandably, the attention will be shifted from Number to Algebra at this level. Number & Algebra should occupy about 40% of the curriculum, and it is broadly structured as follows.

Level	Topic	Learning Objectives
S1-S3	Number and number systems	Negative numbers, ordering of numbers, manipulation of directed numbers Numerical estimation , approximation and errors Rational and irrational numbers
	Comparing quantities	Percentages, percentage changes & practical problems (including simple and compound interests) Meaning of rate, ratio, notation, & solving problems
	Observing patterns and expressing generality	Use of symbols to represent numbers Formulate simple algebraic equations & solve problems Manipulation & factorization of simple polynomials Laws of indices Linear equations and inequalities in one unknown
	Algebraic relations and Functions	Linear equations in two unknowns (solve simultaneous equations) Identities and formulas
S4-S5	Observing patterns and expressing generality	Manipulation of polynomials including division Factor & remainder theorems Arithmetic & geometric sequences and series
	Algebraic relations and Functions	Quadratic equations & nature of solutions; graphs Solving equations by methods such as transformation and graphing Variations: direct, inverse, and others Linear inequalities in two unknowns & solutions Exponential & logarithmic functions, their relation & applications Concept & notation of function Properties and solutions of quadratic functions Graphs of various types of functions & effects of transformations

It is inevitable that any categorization of the secondary curriculum into dimensions cannot be entirely satisfactory, and that overlaps or inconsistencies may seem to occur. The separation into dimensions becomes even more problematic as students think about mathematics in an interconnected way at higher levels, and therefore the dimensions will not be continued beyond S5.

At the S6-S7 level, the new curriculum is still to be decided, because Hong Kong is considering changing from its present secondary + matriculation + university education system of 5+2+3 (years) to a 6 (secondary) + 4 (university) model in several years' time. The existing curriculum consists of Pure Mathematics, Applied Mathematics, and Mathematics & Statistics. These alternatives are intended to provide a choice and preparation for students intending to study different subjects in university, whereas the contents of any selection would be considered university level material in many countries. For example, the Pure Mathematics curriculum contains the contents of a standard course on Calculus & Analytic Geometry, some topics from Linear Algebra, as well as complex numbers; while the Applied Mathematics curriculum includes the topics of Vectors & Mechanics, Differential Equations, Numerical Methods, and Probability & Statistics. In order to provide a smooth transition

from S5 to university in the future, the curriculum should be redesigned so that it is a natural continuation of the new secondary curriculum.

4. Remaining challenges

As Hong Kong proposes to move away from an examination-driven and content-based education system towards one that emphasizes the processes of learning and the development of generic skills, several issues remain to be resolved. These include the need to devise an assessment system that will be consistent with the aims and objectives of the new approach, careful planning to ensure a smooth articulation of the school curriculum with that implemented at the university level, the development of teachers who will be at the forefront of the education reform, and enlisting help from parents to support the reform.

To begin with, the public examinations that students take must be consistent with the approaches and curriculum being implemented in schools, and therefore the examinations must be re-conceptualized and different in nature from those that have been implemented for many years. The examinations should not be filters, but should be assessments that will help to promote student learning according to the newly defined aims and objectives; otherwise there will be a discrepancy that may result in disillusionment. This poses a challenge to the examinations system, which has to consider more diversified assessment means in the future.

In addition, the new secondary curriculum should articulate with those offered in universities. Given the strong emphasis on everyday examples in the school curriculum on one hand, and the abstract nature of higher mathematics on the other, the task involved in bridging the gap is not trivial, and adjustments may be required of universities.

Naturally, teachers have to be the main proponents of any education reform. Teachers trained in the traditional curriculum must be enabled to function competently in the new pedagogical environment through professional development, and they must also acquire familiarity with the use of technology in teaching the subject. This is the case given that the use of technology in teaching has been strongly promoted within the past five years. Considerable effort is required of teachers so that they can be competent and well-prepared in implementing the new approaches. In turn, teacher education institutions are challenged to offer appropriate expertise and assistance to teachers in the process.

Finally, an important source of support for the education reform would have to be the come from parents, who need to be responsive to the goals of the reform, and to support the schools in the process. They must accept and support a system under which their children will not be doing a great deal of standard mathematics homework as in the past, but will be engaged in various forms of project work and other new modes of learning. As a result, the impact and demands of the reform will impact on a large proportion of the population.

Concluding remarks

Hong Kong is aiming to redesign its education system so that students can be enabled to learn beyond the classroom, and the school curriculum must be redesigned so that it can also help students to develop skills that can be useful for life-long learning. Given that mathematics is an important school subject and can provide a basis for learning other disciplines, mathematics education is undergoing an important reform. This poses a significant challenge as well as an opportunity to examine global trends and research results in mathematics education, and to adopt/adapt approaches that are appropriate. Much effort will be required for this to be successful, but its result will have a very important impact on the future of mathematics education locally. From this perspective, mathematics education in Hong Kong is presented with an opportunity for reformulating itself, and educators are urged to accept this important challenge.

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References

Curriculum Development Council (2000). *Report on holistic review of the mathematics curriculum*. Hong Kong: Education Dept.

Lam, C.C., Wong, N.Y., and Wong, K.M.P. (1999). Students' conception of mathematics learning: a Hong Kong Study. *Curriculum and Teaching* 14(2), 27-48.

Mullis, I.V.S., Martin, M.O., Beaton, A. E., Gonzalez, E.J., Kelly, D.L., and Smith, T.A. (1997). *Mathematics achievement in the primary school years: IEA's Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: Boston College.