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Holistic Reform of the Mathematics Curriculum — the Hong Kong Experience

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The Hong Kong mathematics curriculum has launched its reform in recent years. It was the first time that a holistic review of syllabi from Primary 1 through Secondary 7 was made. The curriculum development agency also decided to base the reform on sound pedagogical foundations. That was assisted with academic research where the views of various stakeholders were investigated in detail. Surveys were conducted with students, parents, teachers, employers, university professors, and curriculum designers and they give a full picture of mathematics teaching and learning in Hong Kong. The rich data collected should shed light on the development of mathematics curriculum in other regions with similar socio-cultural and educational settings.

THE CURRENT STATE

Introduction

In recent decades, Hong Kong has undergone many changes. Society has become highly technologised. As it has become increasingly easy to access information, many employers now require their employees to be capable of manipulating information rather than practising routine skills. The function of examinations has also changed: its use as a means of screening students is declining. In addition, the expansion of tertiary education means that the apex of the educational pyramid is broadened considerably. There are now more ways of climbing up the social ladder (Wong 1997, 1998). All these changes have impacts on school curricula and the impact on the teaching of mathematics is especially marked. It is generally perceived that mathematics is a subject for all students. Hence its role in the system of universal education is all the more prominent. However, people also believe that the acquisition of mathematical concepts requires special talent, and this creates a seemingly contradictory image of a "subject for all" (Siu, Siu & Wong 1993). In such a context, a holistic review of the mathematics curriculum has been carried out in Hong Kong.

In the wider context, the apparent academic success of Asian students in international comparisons is especially marked in mathematics (Beaton et al. 1996; Lapointe, Mead & Askew 1992; Robitaille & Garden 1989). While much effort had been made in various areas, trying to explain such a phenomenon (Biggs 1994; Cai 1995; Dahlin & Watkins, in press; Hau & Salili 1991; Ho 1986; Lau 1996; Ma 1999; Stevenson & Lee 1990; Stevenson & Stigler 1992; Stigler & Hiebert 1999; Watkins & Biggs 1996; Wong 1998), it is interesting to note that Hong Kong scored the lowest among Asian countries in the Third International Mathematics and Science Study (Beaton et al. 1996).

While the Hong Kong community has been deeply rooted in the Chinese culture, it also experiences great influences from the west. In addition, school curriculum is examination-driven. Emphasis is highly placed on lecturing and memorisation in Hong Kong classrooms (Llewellyn et al. 1982; Morris 1985, 1988; Zhang 1993). Teachers also use frequently the strategy of disapproval to control social behaviour (Winter 1990). Modern Chinese parents place great emphasis on the achievement of their children (Ho, 1986) and students attribute their success to the paying of effort (Hau & Salili 1991).[1]

The Evolution of the Hong Kong Mathematics Curriculum

In Hong Kong, modern mathematics was introduced in the mid-1960s. In 1981, the

[1] For a fuller account of the background of mathematics education in Hong Kong, please refer to Wong (1997; 1998).

coexisting "modern" and "traditional" mathematics syllabi were unified into one single mathematics syllabus developed by the official curriculum development agency (Wong, 1993).

Mathematics is a general course for all students up to the level of Secondary 5. At the senior secondary school level (Secondary 4 & 5), there is another syllabus called "Additional Mathematics" designed mainly for the science stream. It includes topics in algebra, trigonometry, co-ordinate geometry, calculus, two-dimensional vectors, and complex numbers. It should provide a firm basis for further mathematical study.

At Advanced Level, there are two mathematics syllabi, namely Pure Mathematics and Applied Mathematics. In 1994, two Advanced Supplementary Level mathematics subjects, Applied Mathematics and Mathematics and Statistics, were introduced to broaden the sixth-form curriculum. An Advanced Supplementary Level subject only covers half of the curriculum contents of an Advanced Level subject although the examinations of all these subjects will be taken at the end of Secondary 7. The Applied Mathematics syllabus is for mathematically oriented candidates and the Mathematics and Statistics syllabus is for those who wish to further their study of mathematics but may not intend to specialise in physical sciences and engineering. Details of the educational system and the structure of the mathematics curriculum can be found in the appendix.

Changes in the Last Decade

As regards the general situation of the school curriculum implementation in Hong Kong, one of the many attempts to improve the quality of education was the introduction of the Target Oriented Curriculum. The intention was "to provide clear learning targets to help teachers and schools develop more lively and effective approaches to teaching, learning and assessment" (Education Department 1994, p. 26). The *Target Oriented Assessment Guideline* was released in 1996 and finalised in 1998 (Co-ordination Committee on Evaluation of the TOC Assessment Mechanism 1998).

The Target Oriented Curriculum identifies learning targets within the four key stages of Primary 3, Primary 6, Secondary 3 and Secondary 5. Assessment of these targets would be judged with reference to eight bands of performance. In mathematics, only content areas were considered and "the five dimensions of number, measure, algebra, shape & space, and data handling were identified. These five strands were incorporated with process abilities of mathematical conceptualisation, inquiry, reasoning, communication, application and problem solving" (Curriculum Development Council 1992, p. 12).

At the same time, to help students learn better, the Curriculum Development Council identified a foundation part of the existing mathematics curriculum so that less able students can focus their learning and effort on this subset of contents (Curriculum

Development Council 1996). Since these students need not state themselves which part they will attempt in public examination beforehand (when they can choose between two distinct examination syllabi), the labelling effect is minimal. The measure is well received by both teachers and students (Wong & Suen 1998).[2]

THE HOLISTIC REVIEW

Problems of the Mathematics Curriculum

The present mathematics curriculum has been criticised by teachers and academics (see for example, Wong 1997). Despite the fact that there were new curriculum initiatives such as the Target Oriented Curriculum and curriculum tailoring, all of these innovations were based on the current mathematics curriculum, which is a product of the late 1970s. Wong, Lam & Wong (1995), for instance, pointed out the major problems in primary mathematics education, such as lack of continuation between different learning stages (i.e., kindergarten, primary school and secondary school), relying too much on textbooks, inability to cope with individual differences, and students being driven by aptitude test. At secondary level, Wong, Wong & Lam (1995) identified the following problems:

1) Low motivation to learn to think mathematically,
2) Doubts about the usefulness and relevance of learning mathematics,
3) Teaching approaches undermining mathematical thinking,
4) Examination question types dictating classroom teaching,
5) Unified textbook format reinforcing the status quo, and
6) Poor linkage between curricula in different grades and topics.

In response to these criticisms, a joint working party of the Curriculum Development Council and Hong Kong Examinations Authority was set up in March 1994. Members from different levels of mathematics subject committees set out to reform the mathematics curriculum. After a series of discussions, it was resolved that the primary and secondary curriculum should be reviewed. A high level *ad hoc* committee was set up in the Curriculum Development Council in 1997 to conduct a holistic review of the mathematics curriculum from primary school right up to sixth-form level.

Scope and Work of the Committee for Holistic Review

The *Ad Hoc* Committee on Holistic Review of the Mathematics Curriculum (Curri-

[2] Ditto

culum Development Institute 1998) aims at:

1) Examining the aims and objectives of the mathematics education from Primary 1 to Secondary 7,
2) Examining whether the mathematics syllabi are designed according to the aims and objectives with particular attention to curriculum continuity and coherence,
3) Examining whether the mathematics syllabi are implemented to achieve the aims and objectives,
4) Proposing implementation strategies of the various syllabi and making recommendations on the need of teacher education and the provision of resources.

The *ad hoc* committee, since its inception, has discussed a number of issues on the mathematics curriculum. Opinions were exchanged with various interest groups, including mathematics subject committees at different levels and major providers of mathematics teacher education. Different scholars were also invited to present their observations and findings, including the world trend of the mathematics curriculum and the results of the Third International Mathematics and Science Study.

Key issues addressed in the *ad hoc* committee were consolidated into ten position statements, the themes of which include the role of mathematics in the school curriculum, learning dimensions in the mathematics curriculum, catering for learner differences, curriculum differentiation at senior levels, mathematics for pre-primary education, implementation strategies, assessment in the mathematics curriculum, the use of information technology, and the quality of mathematics teacher.

The *ad hoc* committee perceives that more in-depth understanding of the curriculum matters is essential before any concrete decision can be made. A supportive research study was thus commissioned to a research team of which the authors of this paper were the team members. The study was conducted from April 1998 to July 1999.

Supportive Research

We believe that situational analysis is the first step in curriculum development (Lawton 1989; Skilbeck 1984). We also believe that a curriculum review should cover the following tasks (Popham 1993):

a) Assessing the weaknesses and strengths of the present curriculum and identifying areas that need to be improved,
b) Understanding the social and political developments in the society,
c) Depicting a clear picture of how teachers teach and how students learn,
d) Detailing recent development in the subject discipline, and
e) Finding out the expectations of students, schools, teachers and employers towards

the school education.

Based on the above, a research plan for the holistic review of the mathematics curriculum was developed (see Figure 1). The aim is to analyse the current mathematics curriculum in Hong Kong and to solicit the views of different stakeholders, including students, teachers, parents, employers, curriculum designers, and university professors, on the mathematics curriculum.

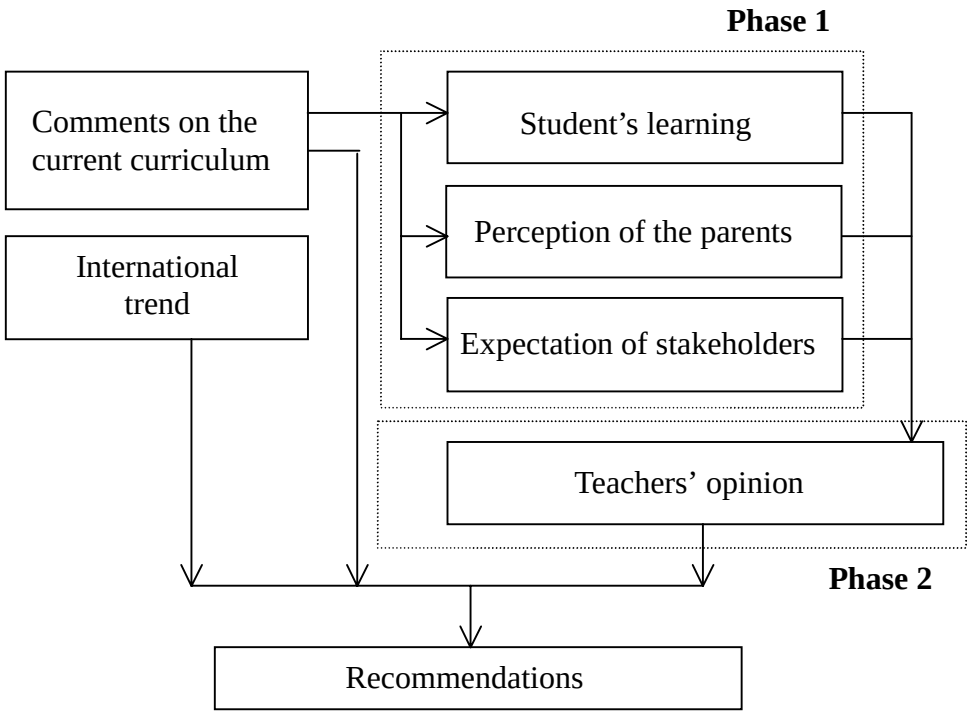

Figure 1. The Research Plan

Both quantitative and qualitative methods were utilised since the data to be collected were multifarious. The research methodology is given in Table 1

Details of the research can be found in Wong et al. (1999). The following is a brief account of the research findings.

Findings

Views of Students

A questionnaire was administered to nearly 9,000 students. We found that students had a high regard for mathematics and preferred deep understanding of the curriculum rather than rote memorisation. For instance, in Primary 3, 65% of the respondents showed

interest in attending mathematics classes and 66% of them believed that once they fully understand the topic, they can find ways to solve problems.

Table 1. Methodology of the research

Research questions	Methodology employed
(a) To study students' views at various learning stages on: (i) Their attitudes towards learning mathematics, (ii) The actual effort paid in learning mathematics, (iii) Their comments on the learning experiences, and (iv) The problems they face in learning mathematics.	A 5-point-scale questionnaire on students' attitudes towards learning mathematics and their learning habits (30 items: Wong & Cheng, 1991), their conception of mathematics (27 items: Wong, Lam & Wong, 1998) and their beliefs in mathematics (13 items: Schoenfeld, 1985) was administered to a random sample of 90 primary and 50 secondary schools. In each of these schools, two classes were selected from the grade levels P.3, P.6, S.3, S.5 or S.6. A total of 8,988 students responded. Semi-structured group interviews (in groups of four students) were conducted for three groups from each of the grade levels P.3, P.6, S.3, S.5 and S.6. A total of 15 groups (60 students in all) were interviewed.
(b) To study parents' views on the current school mathematics curriculum and their expectation of changes at various learning stages.	The parents of the above random sample of students from 90 primary and 50 secondary schools were invited to respond to a questionnaire on their views of the current school mathematics curriculum and their expectation of changes at various learning stages. The questionnaire comprises 21 questions, eight of them on their beliefs on mathematics learning, seven on their knowledge on the mathematics curriculum, and six on the learning difficulties their children encountered, the year such difficulties arose and how they helped their children overcome these difficulties. They were also asked how much time per week their children spent on their homework in general and on mathematics homework in particular, and the number of hours they spent on helping their children learn mathematics.
(c) To study teachers' views on: (i) The current school mathematics, curriculum at various learning stages, (ii) The problems they face in teaching (iii) Their expectation of future development, and (iv) The support they will need in the implementation of a new mathematics curriculum.	The chairpersons, or their representatives, of the mathematics panels of the above sample of 90 primary and 50 secondary schools were invited to respond to a questionnaire. The questionnaire consists of six parts, namely, their satisfaction with the existing curriculum, perceived usefulness of teacher education, major problems in mathematics education, methods to cater for individual differences, use of information technology, and their beliefs on mathematics learning. The inventory used in Perry, Tracey & Howard (1998) was used for the last part. Follow-up interviews were conducted among teachers from five primary schools and five secondary schools.

Table 1 (continued). Methodology of the research

Research questions	Methodology employed
(d) To solicit views of various key stakeholders, including employers (from human resources perspective) of various sectors, educators of tertiary institutions/universities, etc. on: (i) Their general opinions of school mathematics education, (ii) The strengths and weaknesses of school-leavers in mathematics-related abilities, and (iii) Mathematics-related abilities that need to be further developed.	Semi-structured interviews were conducted with human resources personnel of five enterprises in the field of science and technology (and related areas). Semi-structured interviews were conducted with 17 lecturers in related departments (including natural sciences, social sciences, computer science and engineering) in tertiary institutions. One current and/or ex-members from each of the mathematics subject committees (primary, secondary and sixth-form) of the Curriculum Development Council, one curriculum planner in the science or humanity field, together with mathematics subject officers of the Hong Kong Examinations Authority, were also interviewed.

Students also wished to know how to derive and apply formulae. They found interest in learning mathematics at a younger age but such an interest declined when mathematics learning were becoming more and more difficult at higher grade levels.

The mean score (on a 5-point scale) in the response to the questions "I fully understand the content of the mathematics class" dropped from 3.61 to 2.38 as we moved from Primary 3 to Secondary 6.

Besides, students experienced the greatest pressure from homework at Primary 6. Some 45% of them hoped for having less homework. Topics that involved tedious calculations such as mixed manipulations of the four rules and word problems were least welcome. Word problems were also thought to be difficult. 76% of Primary 3 students and 33% of Secondary 6 students hoped that mathematics teaching could be more lively and mathematics textbooks could provide more real-life applications. Secondary school students felt that the syllabus at the junior secondary level was too fragmented and topics at Secondary 1 overlapped much with those at primary levels. Senior secondary school students showed dissatisfaction with the whole senior secondary and sixth-form mathematics curriculum structure. They reflected that the syllabi could not cater for their needs.

Interviews with 60 students further reinforced the above findings. Students generally saw mathematics as a set of rules. At the same time they realised that to solve a mathematical problem, the way one approaches a question and applies a formula and even one's way of thinking are important factors determining its success. Therefore, they saw homework as an important component of mathematical learning and hoped that teachers could provide them with sufficient exercises to provoke their thinking. A good mathematics teacher, they thought, is someone who is nice, teaches lively, provides a variety of activities, and offers clear and step-by-step explanation. S/he allows time for

students to think, assesses students' understanding from time to time, explains how to approach problems, and would not penalise less able students. They reflected that their interest in learning mathematics was closely related to whether they could obtain a sense of success in solving mathematical problems. Same as the questionnaire results, students disliked topics that involved tedious calculations, or those easy-to-make mistakes, impractical or difficult ones. Besides, students further pointed out that the curriculum was too packed in general and the situation was even more serious at the senior primary level due to over-drilling for the Academic Aptitude Test. Some students found the use of computer software in teaching mathematics a waste of time.

Views of Parents

A questionnaire was administered to over 6,000 parents. We found that parents showed high regard for mathematics with a mean score of around 4.7 on a 6-point scale. They also held a positive view towards the mathematics curriculum. Their children's interest in learning and understanding of the curriculum was their sole concern. Their hopes were consistent with what were found among the students, such as clear explanation from teachers, motivation of students' interest, provision of thought-provoking exercises, and monitoring students' understanding from time to time.

It was also found that parents gave much support to their children's learning of mathematics. While 78% of the parents of Primary 3 students spared time in helping their children learn mathematics, about 30% of them, especially those parents of students at lower grade levels, also employed private tutors for their children. To them, the major problems of learning mathematics among their children were carelessness and inability to interpret mathematical questions. Therefore they believed in the importance of paying effort and practices. When their children moved up the grade levels, they did not possess enough knowledge of the curriculum and they were more likely to rely more on drilling with exercises. Besides, they generally held a negative view towards the Academic Aptitude Test and the quality of mathematics textbooks.

Views of University Professors

Interviews with university professors from nine departments gave us a picture of their expectation of our school mathematics curriculum. They were generally satisfied with students' mathematical standard and the mathematics curriculum. They saw the scores in public examinations reliable. Although the demand on mathematical skills varied across different departments, most of these departments could admit students of the appropriate calibre. The only possible exception was the department of mathematics who hoped to enrol students with a strong mathematical foundation but in reality this was not always the case. As regards the school mathematics curriculum, some professors preferred to

broaden the breadth of students' knowledge while others emphasised the depth. However, in general they agreed that a firm foundation and a mathematical sense were of utmost importance. We also found that most of them did not have much idea of the existing mathematics curriculum nor of what was currently going on in school mathematics.

Views of Human Resources Personnel

Interviews were conducted with human resources personnel in five enterprises. Most employers were satisfied with students' performance too. They considered an employee's language ability and work attitude more important than his/her mathematical knowledge. However, analytical power, problem-solving skill and a mathematical sense were thought to be important skills in most careers.

Views of Curriculum Planners

Five curriculum planners were interviewed. The science curriculum planner was satisfied with the mathematics curriculum, saying that it could provide the necessary mathematics tools for science subjects. However, interviews with mathematics curriculum planners at various levels showed a different picture and revealed various problems of the existing mathematics curriculum, such as lack of continuation between kindergarten and primary mathematics, and inability to cater for individual differences at Certificate of Education level. They also considered the current curriculum too packed in general, and both Pure Mathematics and Applied Mathematics too difficult. Some of them suggested a shift of emphasis from computation to conceptual understanding in the curriculum. They showed discontent on overemphasising examinations in the community. The mathematics curriculum planners also urged for more communication between primary and secondary school teachers to improve coordination between these two levels.

Views of Teachers

A total of 370 primary and 289 secondary mathematics teachers responded to the questionnaire for teachers. Over 90% of them felt that they possessed adequate mathematics knowledge to teach except in the areas of calculus and classical mechanics in the sixth form where some teachers did not have sufficient confidence. Over 70% of them perceived the ability and motivation to learn were the major problems of learning mathematics among students. Also over 70% considered mixed ability another key issue. The teachers felt that students performed less well in those topics that involved tedious computation.

As for the curriculum, most mathematics teachers reflected that it was too bulky, lacked flexibility, and was unable to cater for individual differences and to provoke thinking. The content was found to be dry too. Teachers tended to deal with individual

differences in their own ways. They were not inclined to use such systematic methods as setting different assessment standards for different classes because of their concern about "fairness." Less than 15% of the teachers incorporated information technology in their teaching. When mathematics teachers wanted to seek help in their teaching, collegiate exchange, referring to their own school experience and textbooks would be their preferences. Comparatively, they seldom took curriculum documents or seminars as a source of help. It is noteworthy that many primary school teachers did not have strong mathematics background. Slightly less than 50% of primary teachers were non-degree teacher certificate holders who did not major in mathematics. Besides, about 70% of mathematics teachers urged for a reduction of workload, particularly of non-teaching duties.

The above findings are consistent with what were found in the interviews with 14 primary and 20 secondary mathematics teachers. They said that students were good at mechanical computation but weak in conceptual understanding and higher order thinking. Students had a short attention span and when they moved up to the secondary level, different problems emerged, like being passive, lack of initiatives and earnest to learn. Another serious problem was that they lacked a solid foundation. Almost all teachers pointed out that the existing mathematics curriculum was too packed, too boring, impractical and unrelated to real life. They advised that continuity at all levels must be secured. Contents and level of difficulty should be rearranged with a strong epistemo-logycal and pedagogical foundation. If streaming is to take place at the senior secondary level, then opportunity for further mathematics studies at the sixth form must be offered as a viable option. The idea of a core and extended curriculum seems to be workable but we must let parents understand the rationale behind. Teachers agreed that higher order abilities should be addressed and the curriculum should be trimmed down to leave time and space for this to take place. Teachers generally showed high regard for information technology but they lacked guidance and support at all levels. Furthermore, they considered the use of information technology time-consuming. All in all, time was a big concern for teachers. Teachers needed more time to prepare teaching material, and therefore they suggested to reduce teacher-student ratio, class size and teaching workload, and to improve the crowded workplace, their morale and the social recognition of their profession.

Conclution

The above findings gave a clear picture that the current mathematics curriculum was well supported by various stakeholders though there is room for improvement. They cast

great trust on the existing system and saw mathematics as an important subject. Both students and parents showed high regard for mathematics and they all emphasised the importance of understanding rather than learning by rote. These are advantageous to the mathematics curriculum reform. Students, parents and teachers all thought that one of the strengths of the current curriculum is to provide the training of basic skills for the students so that they could have a solid foundation. This is also reflected in the results in international comparative studies. Teachers also found the curriculum clear and easy to follow. We think that care should be taken to retain these strengths in the future mathematics curriculum innovation.

To go for "mathematics-for-all," mathematics should no longer be taught just as a tool in school, but should be taught as a subject which possesses an expanding goal that reflects the diverse roles mathematics plays in the society. To maintain the interest of learning mathematics, mathematics should be taught in a more lively and interesting way. Textbooks should thus build in a variety of learning activities including real-life examples and exercises that provoke thinking. The position and use of information technology in mathematics education is an issue of concern to different groups of stakeholders but teachers showed hesitation to apply the technology in their teaching due to the lack of direction and guidance. We see that further developmental research is needed to explore how and when information technology can be used to make mathematics learning more effective.

Individual differences among the students, including their future needs as they enter different walks of life, is a major issue in the period of universal education. For the post-universal education stage, i.e. senior secondary and sixth-form levels, curriculum differentiation has to be considered which includes the reorganisation of the senior secondary and sixth-form curriculum structure. In order to address higher order thinking and other process abilities, the curriculum should be enhanced to ensure continuation at different levels and to avoid overlapping and fragmentation. Unnecessary mechanical calculation and impractical topics should be removed. Thus, if there should be a trim-down of the contents, it is only reasonable when we want to spare room for deeper understanding of the material rather than go for a watered-down curriculum. We need strong theoretical foundation to reorganise the contents of the mathematics reasonably.

Any curriculum cannot be successfully implemented without teachers. On the one hand, teachers should play an active and important role in the new curriculum, which should not be a document merely passed to the teachers to follow closely. On the other hand, the implementation of the new curriculum is demanding on the teacher's side. Mathematics teachers are expected to teach more lively to maintain students' interest and confidence in doing mathematics and to give them a sense of success. They should also possess the ability to handle classes with mixed ability and cater for individual differ-

ences. Mathematics teachers should address higher order thinking and sense-making of mathematics and enhance problem-solving abilities among the students. They should consider the appropriate use of information technology to make both their teaching and students' learning more effective. They should widen their conception of mathematics and of mathematics learning too.

All these cannot be achieved without the upgrading of teacher professionalism. Teacher training and support are important. Guidance to teachers on various issues like curriculum tailoring and use of information technology is beneficial. Collegiate exchange among mathematics teachers both within schools and in the mathematics education circle should be encouraged. In particular, communication among mathematics teachers at primary and secondary levels should be strengthened. The Academic Aptitude Test is found to be disturbing and needs to be reviewed. The emphasis on higher order abilities should be reflected in assessments but every effort should be made to safeguard against backwash effects. We also see that reliable test items of higher order abilities are not fully developed worldwide and research on this area is necessary before the implementation of the idea. Different stakeholders, in particular university professors and parents, should be fully informed of the spirit of the new curriculum. Parents' understanding of the curriculum would guarantee meaningful support to their children's mathematics learning and this in turn will help students learn better.

Significance and Implications

Recommendations on the Mathematics Curriculum Structure

The study depicted a holistic picture of the Hong Kong mathematics education and indicated where it should head towards. At the curriculum level, the urge for restructuring the mathematics curriculum structure at senior secondary level is clear. The existing two mathematics syllabi at Secondary 4 and 5 and the four syllabi at Secondary 6 and 7 should be restructured to cater for individual differences and to secure the continuation at these levels. Labelling effect of a second-class curriculum should be played down if there is curriculum differentiation. At the same time, mathematics curriculum at the sixth-form levels should not be designed solely for those who will proceed to tertiary mathematics and/or engineering education. Curriculum tailoring, i.e., identifying the foundation part of mathematics curriculum, is desirable and should be done on a strong epistemological and pedagogical basis. Fung & Wong (1997) provides a good framework for Primary 1 to Secondary 5. The framework was designed on the basis of epistemological considerations which could safeguard against fragmented curricula.

Implementation Strategies

The research team recommend that the Curriculum Development Institute, the official arm of curriculum development, should develop and issue clear guidelines and exemplary material for teachers, textbook writers and textbook publishers to develop suitable and sufficient teaching material. A group of high-calibre full-time professionals in the central agency is also necessary to provide strong supports and guidance for school teachers to tailor-make teaching strategies for their students.

Communication with different stakeholders to explain the need and orientation of curriculum changes is essential to the successful implementation of the new curriculum. The notion of minimal competence by criterion referencing at different key stages can be explored.

Assessment

While assessment should meet the trend of the new curriculum to effectively collect the feedback of students' learning, it should take every possible precaution to safeguard the curriculum against being driven entirely by examinations. Although assessment of higher order thinking is needed, it should be noted that reliable assessment items are yet to be fully developed around the world. Therefore, it is not advisable at the moment to incorporate them extensively in high-stake examinations.

However, mathematics teachers could improve their teaching if they could keep diagnosing their students' learning progress during the course of teaching. In fact, students did hope that teachers could examine from time to time their understanding of the curriculum contents. Besides, for public examinations for General Mathematics at Certificate of Education level, the creation of different papers to cater for different tiers is worth exploring.

Learning Interest at Early Years

Mathematics learning of students at the stage of primary school education is of fundamental importance to their learning in higher grades because their interest in mathematics at that stage is still high.

Students' motivation of learning should be cultivated so that they can gradually develop their interest in mathematics. In this sense, graduation from school can really become the starting point of life-long learning. Students' interest of learning mathematics can be cultivated by various means. For example, to explain to them how to derive and apply formulae is one of the means. To let them understand the usefulness of mathematics in different professions and to introduce various topics with real-life examples

could also reinforce their interest.

However, it is essential to let them get first-hand experience of doing mathematics so that their endeavours to mathematical discovery could go beyond intellectual curiosity. It is also worthy to note that confining mathematics learning to artificially created so-called real-life situations could deprive the students of genuine mathematics learning.

Teachers

We need a strong teaching profession where teacher can see the needs and progress of their students and tailor-make learning activities for them. As such, teachers' conceptions of mathematics and mathematics learning should be widened. The mathematics knowledge in formal (pre-service) teacher education courses should be strengthened and long-term institutionalised (instead of piecemeal) in-service programmes should be developed so that teachers are given the encouragement, opportunity and support (e.g., provision of supply teachers) to upgrade themselves. We should create a multiple channel for teachers to develop, experiment and share various teaching strategies. This could be done in collaboration with professional bodies so as to create a culture of collegiate exchange. Nevertheless, all these could not be realised if the existing workload of teachers cannot be reduced.

Looking Ahead and Implications

The research study generated rich data and the *ad hoc* committee is incorporating these results into a final report. Based on the report, the mathematics curriculum will be restructured and the contents of each syllabus redesigned. However, we do not expect drastic change in terms of contents. What is significant lies in how mathematics is presented by the teachers and experienced by the students. Motivation of students' interest, their understanding of the relevance of mathematics and the emphasis on higher order thinking are of utmost importance. All these should be conveyed to teachers, parents and other stakeholders.

The holistic review of the mathematics curriculum also has long-term significance in the curriculum development in Hong Kong. Curricula in other subjects should also be developed with a holistic consideration from primary to secondary levels. Curricula should be developed on the basis of solid academic research and pedagogical considerations and new curriculum should not be viewed as a task that is to be completed at one stroke. While full consultation with stakeholders should be done before the curriculum is developed, in-service teacher development and teacher support should be provided afterwards. The rich data collected should shed light on the development of mathematics curriculum in other regions with similar socio-cultural and educational

settings.

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APPENDIX: BACKGROUND OF THE EDUCATION SYSTEM

Since the introduction of universal education in 1978, a child growing up in Hong Kong receives nine years' compulsory primary education (from Primary 1 to Secondary 3), with secondary school places allocation monitored by the Academic Aptitude Test in between. Although senior secondary education (Secondary 4 & 5) is not compulsory, about 90% of junior secondary school students are eligible for promotion to Secondary 4. These students would sit the Hong Kong Certificate of Education Examination at the end of Secondary 5. The promotion rate from Secondary 5 to Secondary 6 in recent years is around 40%. To gain entry into university, sixth-formers sit the Hong Kong Advanced Level and Advanced Eplementary Level Examinations after two years' study(see Figure 2).

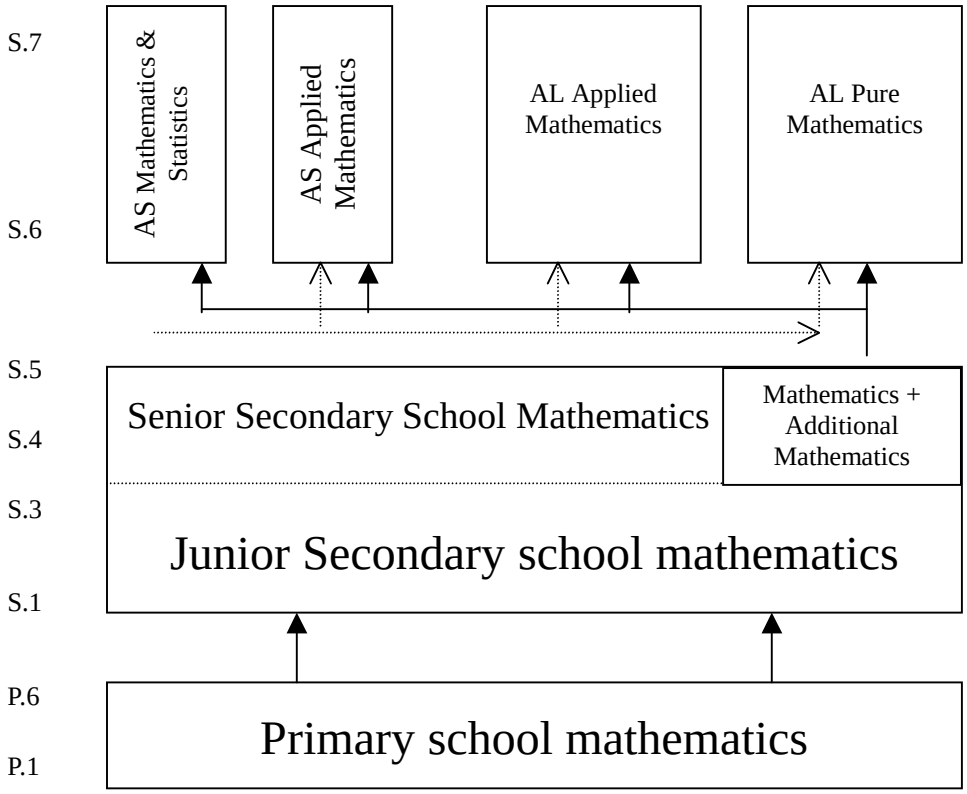

Figure 2. The Hong Kong mathematics curriculum structure

Similar to many Asian countries, classes in Hong Kong are large with around 40 students per class. This is one of the highest among participating countries at the IEA's Third International Mathematics and Science Study (Leung et al. 1999).