EXECUTIVE SUMMARY

The research was commenced in April 1998 and was completed in June 1999. The views of students, parents, teachers, university lecturers, curriculum planners and human resources personnel in the commercial sector were solicited and the whole project progressed smoothly. The data arising from these studies were supported by results from another research commissioned by the Education Department [(*)].

Background

In response to the need for a review and possible reform in the mathematics curriculum in Hong Kong, the Ad-hoc Committee for Holistic Review of the Mathematics Curriculum was set up in the Curriculum Development Council as it was thought that research on the strengths and weaknesses of the present curriculum and views of various stakeholders could not only provide useful information for curriculum planners in the development of a new curriculum, but could also generate first-hand data which could improve teaching and learning at the classroom level. It was with this intention that the Education Department commissioned the present research.

Research questions and methodology

In order to achieve the objectives, the following research tasks and questions were set:

(a) To study students' views at various learning stages on (i) their attitudes towards learning mathematics; (ii) their actual effort made in learning mathematics; (iii) their comments on the learning experiences; and (iv) the problems they face in learning mathematics;
(b) To study parents' views on the current school mathematics curriculum and their expectation for changes at various learning stages;
(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 on future development; and (iv) the support they will need in the implementation of a new mathematics curriculum in future;

[(*)] Comparative study on the mathematics curricula of major Asian and western countries commissioned by the Education Department conducted by the same research team.

(d) To solicit views of various key stakeholders, including employers (from the human resources perspective) in various sectors of the employment field, educators of tertiary institutions/universities, etc., on (i) their general opinions on 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; and

(e) To compile suggestions made in another research[*] and feedback collected in consultation to make recommendations (with alternatives, and the pros and cons for each alternative) on (i) the overall aims of future school mathematics education, aims and objectives of the future school mathematics curriculum at various learning stages; (ii) the design and general layout of mathematics curriculum at various learning stages; (iii) modes of courses and modes of assessment; (iv) changes necessary to achieve the aims; and (v) strategic plans, both short-term and long-term, in implementing the recommendations.

Both quantitative and qualitative methods were utilised since the data to be collected are multifarious. Student and parent questionnaires were administered to a random sample of 10% of local primary and secondary schools. Open-ended questions were incorporated into the questionnaires. In-depth semi-structured interviews were conducted among students, university lecturers, curriculum planners and human resources personnel. Three basic research studies conducted by team members were also incorporated into the present one.

Results from another research

Review of literature revealed that individual differences and mixed abilities are major issues of concern for mathematics education in the next century. Flexibility of the curriculum is asked for to cater for the above. In a pluralistic and highly technological society, mathematics should be taught as a subject which possesses several very different goals that reflect the diverse roles mathematics plays in the society. Mathematical knowledge, concepts, problem solving skills as well as abilities to discover and to invent should be encompassed. The development of assessment of high order thinking is a world issue but we should, at the same time, safeguard against having the curriculum driven by examinations. Both the "content" and "process" of mathematics learning have to be taken care of.

[*] Comparative study on the mathematics curricula of major Asian and western countries commissioned by the Education Department conducted by the same research team.

Cultivation of interest in learning mathematics is important too. In fact, international comparisons revealed that, though Hong Kong students performed well in mathematics tests, they lacked confidence in solving mathematical problems. How and when information technology could be used to enhance mathematics learning is another important issue that is urgently needed to be explored. In order to leave room for cultivating the motivation of student learning and the development of higher order abilities, the scope and depth of the current curriculum content have to be re-considered. Again, international comparisons revealed that in Hong Kong, on the average, topics were taught one or two years earlier than in other countries. All these new ideas cannot be accomplished without the professionalism of mathematics teachers. Previous research did reveal that student learning in mathematics was greatly influenced by the teacher.

Students' views

By the use of student questionnaires administered to nearly 9000 students, we see that students possessed a high regard for mathematics and preferred deep understanding rather than rote memorisation. They wished to know how formulas come about and are applied. They found interest in learning mathematics at a young age though such an interest declined and they found mathematics learning more and more difficult at higher grade levels. They experienced the greatest pressure from homework at Primary 6. Topics that involved tedious calculations were least welcome and word problems were thought to be difficult. Students hoped for liveliness and real life applications both in teaching and in textbooks. Secondary school students felt that the syllabus at the junior secondary level was too fragmented and there was much overlapping of topics at Secondary 1 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 syllabuses could not cater for their needs.

Interviews with 60 students further reinforced these findings. Students generally saw mathematics as a set of rules. At the same time they realised that the way one approaches a question and applies a formula and even one's way of thinking were important if one was to solve mathematical problems. They saw homework as an important component of mathematical learning and so they hoped that teachers could provide them with sufficient exercises that provoked thinking. Their image of a good mathematics teacher was someone who is nice, lively, provides a variety of activities and offers clear, step-by-step explanation, who allows time for students to think, checks frequently to see if students understand from time to time, explains

how to approach problems and would not penalise weaker 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. As found in the questionnaires, students disliked topics that involved tedious calculations, were easy to make mistakes, impractical or difficult. Besides those discontents on the curriculum found in the questionnaires, students further pointed out that the curriculum was too packed in general and the case 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.

Parents' views

The questionnaire was administered to over 6000 parents. Parents showed high regard for mathematics and held a positive view towards the mathematics curriculum as reflected in the parent questionnaire. Students' interest and understanding were their sole concern. Consistent with what was found among the students, parents hoped for clear explanation, motivation of interest, provision of exercises that provoke thinking and checking of students' understanding from time to time from the teacher. Parents showed great support to their children's learning of mathematics. They were willing to help with their children's learning and many of them, especially parents of students at lower grade levels, employed private tutors for their children. They believed in paying effort and relied on practices. To them, the major problems among students were carelessness and inability to interpret the questions. As their children moved up the grade levels, parents possessed less knowledge of the curriculum and there was a tendency of relying more on traditional ways of learning, like drilling with exercises. Parents generally held a negative feeling towards the Academic Aptitude Test and the quality of mathematics textbooks.

University lecturers' view

Interviews with university lecturers from nine departments gave us a picture of what they expected of our school mathematics curriculum. They were generally satisfied with students' standard and curriculum and saw the scores in public examinations as reliable. The demand on mathematics varied across departments and basically they could admit students of the appropriate calibre through competition of examination results. The only possible exception was the department of mathematics where they hoped to get students with a strong mathematical foundation and in reality this was not always possible. Some

lecturers asked for breath and some asked for depth in the school mathematics curriculum but in general, a firm foundation and a mathematical sense were of utmost importance. However, most of them did not possess much idea of the existing mathematics curriculum nor what was currently going on in school mathematics.

Views from human resources personnel

Interviews were conducted with human resources personnel in 5 enterprises. Most of the employers were satisfied with students' performance too. They saw language and attitude more important than mathematical knowledge. However, analytical power, problem-solving skill and a sense of numbers were important in most of the careers.

Views of curriculum planners

Five curriculum planners were interviewed. The curriculum planner in the science area was satisfied with the mathematics curriculum, saying that it could provide the science subjects with necessary mathematics tools. Interviews with mathematics curriculum planners at various levels revealed various problems of the existing mathematics curriculum. Lack of continuation from kindergarten to primary mathematics, inability to cater for individual differences at Certificate level, curriculum too packed in general, both Pure Mathematics and Applied Mathematics being too difficult were some of the problems they raised. Some suggested a shift from computation to conceptual understanding in the mathematics curriculum. They showed discontent on the over-emphasis of examinations in the community. The curriculum planners also urged for more communication between primary and secondary school teachers to improve coordination between these two levels.

Teachers' view

A total of 370 primary and 289 secondary mathematics teachers responded to the teacher questionnaire. Results revealed that mathematics teachers felt they possessed adequate mathematics knowledge to teach except for calculus and classical mechanics in the sixth-form where some teachers did not have sufficient confidence. Ability and motivation to learn were perceived as the major problems among the students in learning mathematics. Mixed ability was another key issue too. The students performed less well in those topics that involved tedious computation. As for the curriculum, most of the mathematics teachers who participated in the survey reflected that it was too bulky, lacked flexibility, was unable to cater for individual difference and to provoke thinking. The content was

found to be dry too. Teachers had a tendency to tackle individual differences themselves and were not inclined to more systematic ways such as setting different assessment standards for different classes, where fairness was an issue of concern. Not many of the teachers incorporated information technology in their teaching at the moment and when they wanted to seek help in their teaching, collegiate exchange, their own school experience and textbooks would be their preferences. They seldom took the curriculum documents or seminars as a source of help. It is note-worthy that many primary school teachers did not have strong mathematics background and generally urged for a reduction of workload, in particular of non-teaching duties.

The above is consistent with what was found in the interviews with teachers which were conducted among 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 at the secondary level different problems emerged, namely, students being passive, unable to take the initiative and not being serious about learning. Another serious problem was that they lacked a solid foundation. Almost all teachers pointed out that the existing mathematics curricula were 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 epistemological and pedagogical foundation. If streaming is to take place at the senior secondary level, then opportunity for further mathematics studies at 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 this notion. Teachers agreed that higher order abilities should be addressed. 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 to be time-consuming. All in all, time was a big concern for teachers. Teachers needed more time to prepare teaching material. Suggestions from teachers included reduction in teacher-student ratio, class size and teaching workload, improvements to the crowded workplace, teachers' morale and social recognition of their profession.

Conclusions

The above results gave a clear picture that the current mathematics curriculum was

well supported by various stake-holders though there are rooms for improvements. They cast great trust on the existing system. Both students and parents showed high regard for mathematics and they all opted for understanding rather than learning by rote. These are advantageous factors for the mathematics curriculum reform. Students, parents and teachers saw the basic skills as some of the strengths of the current curriculum and it can provide the students with 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 such strong points should be retained in the future mathematics curriculum innovation.

To go for "mathematics-for-all", mathematics should no longer be taught in school just as a tool, 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 which young students already have, mathematics should be taught in a more lively and interesting way. So, textbooks should 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 stake-holders but teachers showed hesitation in using it 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. To cater for such needs, 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 content, it is only because we want to spare room for deeper understanding of the material rather than going for a water-downed curriculum. We need strong theoretical foundation to reorganise the content of the mathematics reasonably.

Any curriculum cannot be successfully implemented without the teacher. We see that the teacher should play an active and important role in the new curriculum. It should not be a document that is passed to the teachers for them to follow closely.

On the other hand, the implementation of the new curriculum is demanding on the teacher's side. The teachers are expected to teach more lively to maintain students' interest and confidence in doing mathematics and to give them a sense of success. The teachers should also possess the ability to handle mixed-ability classes and cater for individual differences. They should address higher order thinking and sense-making of mathematics and enhance problem-solving abilities among the students. Mathematics teachers should consider the appropriate use of information technology in their teaching to make mathematics learning more effective. Teachers should widen their conception of mathematics and of mathematics learning too.

All these cannot be done 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 there is an urgent need for review. 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 it is necessary before the actual implementation of the idea. Different stakeholders, in particular university lecturers 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 so that students can learn better.