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Secondary School Mathematics Curricula

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Mathematics has long been an internationally-accepted subject in school curricula. In most systems between 12 and 15 per cent of student time is devoted to mathematics. Kamens & Benavot (1992) focused on the official primary curricula of mathematics and science in a large number of countries between 1800 and 1986, and showed that by the turn of the 20th century both arithmetic and science were firmly established in most countries. They also showed that national differences in the curricular content of mathematics and science were small, and that key indicators of socio-economic development, economic dependence, or world system position did not correlate much with instructional time. Oldham (1989), after trying to find out whether there was an international secondary mathematics curriculum, stated (p.212) that:

> it can be said that there is indeed an international mathematics curriculum. However, the commonalty is moderated by distinct (and less distinct) patterns of diversity; so a better conclusion is that there are several international curricula, sharing many features but with roots in different mathematical and contextual traditions.

Further examples from the 21st century include international studies such as the Third International Mathematics & Science Study (TIMSS) and the OECD-sponsored Program for International Student Assessment (PISA), which have worked with an assumption of universal mathematics and an international mathematics curriculum (FitzSimons 2002, p.110).

In order to understand the stability and change of school mathematics curriculum, some researchers have adopted a world system perspective by emphasising the influence of Western culture, whereas others have focused on local shaping forces in Western developed countries. Kamens & Benavot (1992) suggested that their above-mentioned findings could be explained by the growing transnational forces and worldwide institutionalised cultural rules originating from Western culture.

In a study of stability and change in the School Mathematics Project (SMP) in the 1960s in the United Kingdom, Cooper (1985) used sociological analysis to investigate the nature of school mathematics as a subject, and the process, nature and control of its redefinition. He identified the sources of innovations and the higher institutional decision-making processes which determined which innovations would be filtered through to schools and other educational institutions.

Related work by Moon (1986) focused on the New Mathematics Movement in France, England & Wales, the Netherlands, West Germany and Denmark from 1960 to

1980. The general pattern identified was that while the universities had a major impact on the reform, the 'high status' of New Mathematics was used, or later abused, by material and ideational interest groups. Moon also argued that commercial publishers were influential in the New Mathematics debate. Similarly, Stanic (1987a, 1987b) studied mathematics education in the USA at the beginning of the 20th century. He noted the decline in the influence of 19th century mental discipline theory and the rapid societal changes brought by industrialisation, urbanisation and immigration. In response, various curriculum interest groups argued for their distinct ideas of selection and organisation of school knowledge. In the field of mathematics, the justification question was not the heart of the issue, but conflict, continuity, and compromise emerged in the struggles and controversies.

In the light of such literature, this chapter compares the stability and change of secondary mathematics curriculum in Hong Kong and Macao. Both worldwide and local shaping forces are examined. Adoption of textbooks before World War II is studied first in order to understand the common origin of the traditional approach to mathematics teaching and learning in Hong Kong and Macao. The Communist threat in the late 1940s and the different reaction of the two colonial governments marked the point of bifurcation – the advent of locally-published textbooks in Hong Kong in the early 1960s. Differences in response to the worldwide Modern Mathematics movement by the local mathematics educators brought further diversity in mathematics curricula. Finally, differences in curriculum development organisations are discussed in relation to the late-colonial and postcolonial challenges including universal free education and advance of information technology. The two territories have a common origin in secondary mathematics curriculum, but they moved into different paths in the early 1960s and remained on different tracks. It is unlikely that these two curriculum tracks will converge in the near future.

This chapter also suggests that in the study of stability and change of school knowledge in non-Western places like Hong Kong and Macao, Western influences on mathematics must be considered but local socio-historical background and efforts by local mathematics educators must also be taken into account. The sociology of educational systems proposed by Archer (1979, 1983, 1993, 2000) provides a useful framework to integrate the study of Western influences and local forces into a coherent and illuminating explanatory analysis.

The Common Origin of Traditional Mathematics

Before the 1960s, the mathematics curricula in Hong Kong and Macao secondary schools were mainly textbook-driven. Schools commonly had separate textbooks and even separate teachers for arithmetic, geometry, algebra, trigonometry, coordinate geometry and calculus. The theoretical root of this approach was established over 300 years ago. The traditional organisation of mathematical content was evident in the division of the subject into four main branches: arithmetic, algebra, geometry and analysis, with each considered as a closed and separate field of investigation (Fehr 1970, p.200).

The most popular traditional mathematics textbooks adopted by the Chinese-medium schools in both territories were Chinese translations of American textbooksof the 1910s (K.C. Tang 1999). The most popular algebra textbook was *College Algebra*

written by Fine (1905). The popular geometry textbooks were *Plane and Solid Geometry* written by Schultze et al. (1901). *Plane and Spherical Trigonometry* written by Granville (1909) and *New Analytical Geometry* written by Smith & Gale (1912) were also widely adopted (Hong Kong, Education Department 1955a). These textbooks were also very popular in China in the 1920s (Ngai et al. 1987).

Among the English-medium schools, UK textbooks were adopted. For instance, pre-war textbooks such as *Essentials of School Arithmetic* (Mayne 1938a), *Essentials of School Algebra* (Mayne 1938b), *Modern Geometry* (Durell 1920), and *Elementary Calculus* (Bowman 1936) were included in the approved textbook list for Hong Kong (Hong Kong, Education Department 1955b), and were widely adopted by English-medium schools in both territories from the 1930s. The few Portuguese-medium schools in Macao were in effect Portuguese schools operating in Asia. Portuguese traditional mathematics textbooks were used in these schools.

Finding UK textbooks in the English-medium schools and Portuguese textbooks in the Portuguese-medium schools is not surprising due to the influence of colonialism. However, the adoption of Chinese translations of the American textbooks by the Chinese-medium schools in both places deserves further examination.

In China, after the overthrow of the Qing Dynasty and the establishment of the Republic of China in 1911, a new education system adapted from the Japanese and German systems was introduced. In 1922, this system was replaced by a 6+3+3 system which was adapted from the USA. English versions of the above-mentioned American textbooks were adopted by some prestigious schools in Beijing, including the secondary school of Beijing Normal University. In the 1930s and 1940s, numerous translated versions were published and were popular in secondary schools in the Republic of China (Ngai et al. 1987).

In 1928, shortly after the establishment of the Nanjing government in China, the Overseas Chinese Education Committee was established under the Ministry of Education. Regulations were issued, and overseas Chinese schools were asked to register with the Overseas Chinese Education Bureau. Details of school curricula were required for the registration process (T.C. Cheng 1949; Chen 1992). The main purpose was to control the structures and curricula of overseas Chinese schools in order to exclude Communist influence. The strategic consideration behind such policy might best be explicated by Cheng's (1949) examination of the Hong Kong case (quoted in Wong Leung 1969, p.53):

> Since 1928, the Chinese Government had been trying to control the overseas Chinese schools through its consuls and Kuomintang agents abroad. As there were no Chinese Consuls in Hong Kong and Kuomintang activities were banned, the attempt of the Chinese Government to influence the Chinese colony must be by very subtle ways....
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> One reason why most of the bigger schools had to register themselves with the Overseas Chinese Affairs Committee was that a growing number of Hong Kong students were going back to China for higher studies, and if these schools did not register themselves with the Chinese authorities, their students or graduates would not, as a rule, be recognized in China and therefore could not join any Chinese schools or universities. As registration with the Chinese authorities carried with it an obligation to observe, whether openly or secretly, certain regulations laid down, it was clear that the Chinese authorities had been

having an indirect control or influences over a number of the bigger schools.

The above strategy was quite successful. In 1928, some schools in Hong Kong started to borrow the American 6+3+3 system, like the Chinese-middle schools in China (Sweeting 1990, p.352). Furthermore, as observed by Luk (1991, p.661), in the early 1930s an increasing number of schools were able to operate with branches on both sides of the border and registered with both governments. Hong Kong never developed an autochthonous school system before World War II and remained very much a periphery to its dual centers.

In 1929, in order to counteract the Kuomintang influences, a committee was appointed in Hong Kong to draw up a syllabus for private schools. But the reaction of the Hong Kong government was not successful. In the early 1930s, the vernacular schools had always tried, "as far as the Education Department allowed, to follow the curriculum of the schools in China, using the same textbooks, and having the same subjects" (Wong Leung 1969, p.53).

In 1931, the Overseas Chinese Affairs Commission was established in Nanjing. It signified the need of the Nanjing-based government for a more comprehensive and effective policy towards the overseas Chinese because their support was found to be more necessary with the rise of the Japanese militarism. A survey conducted in 1935 by the Overseas Chinese Affairs Commission to estimate the number of overseas Chinese schools throughout the world found about 550 overseas Chinese schools in Hong Kong and Macao (Chen 1992, p.256). In 1938, when Guangzhou was taken by Japan, the number of schools in Hong Kong and Macao increased dramatically because many institutions moved from the north or from Guangzhou for refuge. The teachers and students of these schools carried with them their curricula and textbooks which had already been adopted by some of the schools in Hong Kong and Macao in the early 1930s. These patterns explain the social origin of the common adoption of USA textbooks by the Chinese-medium schools in both places before the early 1960s.

Bifurcation for Chinese-medium Schools: Local Textbooks in Hong Kong

In Hong Kong, the influence of the pre-war traditional textbooks did not diminish until the early 1950s when the colonial government wanted to exercise its own and exclusive influence on local education due to the political tensions in China built shortly after World War II. The apathy of the colonial government in Macao in response to the similar political tensions created a bifurcation for the mathematics curriculum in the Chinese-medium schools of these two territories.

The Kuomintang nationalistic programme for overseas Chinese education resumed in 1945, and included the publication of textbooks and educational materials (Chen 1992, p.309). In Hong Kong, the Kuomintang started to infiltrate and direct the Chinese press. Running schools was another focus, and in 1946 an estimated 35 private schools in Hong Kong were under the influence of the Kuomintang (Sweeting 1993, p.194). The government's concern about who controlled education was reflected in and increased by several incidents. For instance, in 1948 the Education Department proclaimed that amendments should be made to the ultra-nationalistic segments of Kuomintang-sponsored history, geography, and civics textbooks, and urged that a civics textbook especially prepared in and for Hong Kong should be published

(Sweeting 1993, p.196).

In the late 1940s, the government's wariness about the activities of the Kuomintang was overwhelmed by a new kind of anxiety due to the growing success of the Chinese Communist Party and the increasing intensity of the Cold War. In order to restrict the spread of Communist influence, the Education Ordinance was amended in 1948. It empowered the Director of Education to refuse to register any school teacher, deregister a registered teacher, close any school, and control the curricula and textbooks of all schools (Sweeting 1993, p.199). In 1949, a Special Bureau in the Education Department was set up to fight Communism in the schools. In 1952, as suggested by the Special Bureau, the first Hong Kong Chinese School Certificate Examination was instituted. At the same time, the separate committees on textbooks and syllabuses were replaced by the Syllabuses & Textbooks Committee to perform wider and more positive functions. The new committee's terms of reference were to draw up model syllabuses for use in schools; to advise the Director on textbooks and other teaching aids; and to stimulate the writing and publication of teaching notes and textbooks suitable for the model syllabuses (Sweeting 1993, pp.210-211).

By the end of 1955, the Syllabuses & Textbooks Committee had issued some model syllabuses for primary and secondary schools. A few locally-written textbooks were also produced (Sweeting 1993, p.215). As the least politically-related subject, syllabuses and textbooks for mathematics were not produced until the early 1960s.

Anti-Communism not only brought the first move towards curriculum control by the Hong Kong government; it also induced a gradual change of direction for the Chinese-middle schools, from American style to the English system which was adopted by the Anglo-Chinese schools. In 1961, the pre-war 3+3 system was replaced by the 5+1 system alongside the Anglo-Chinese 5+2 system. One year later a simple syllabus was published by the Education Department (Hong Kong, Education Department 1962), and officially adopted by the government Chinese-middle schools. Although non-government schools were not required to follow this suggested syllabus, their curricula were constrained by the syllabus of the Hong Kong Chinese School Certificate Examination and the entrance examination of the Chinese University of Hong Kong which was established in 1963.

The situation in Macao was very different due to the government's persisting non-interventionist attitude towards education for local Chinese. The long-established relationship between the Nationalist Party and Christianity, especially the Catholic Church, enabled the Kuomintang government quickly to resume its linkage with the Christian schools in Macao after the civil war. In 1954, the Overseas Chinese Education committee in Taiwan started to operate the entrance examination to Taiwan universities for Overseas Chinese (Chen 1992, p.391), and attracted secondary graduates from both Hong Kong and Macao. Unlike Hong Kong, Macao did not have its own school leaving or university entrance examination, and therefore the influence of this entrance examination was particularly significant. One major impact was the maintenance of the 3+3 system by all the Catholic Chinese-medium schools. Therefore, the influence of the Hong Kong published textbooks designed for the 5+1 system was limited, and pre-war textbooks were more popular among these Catholic schools.

The pro-Communist Macau Chinese Education Association (MCEA), as a minor opposing force to the majority of Catholic schools, also started to coordinate its member schools in the early 1950s (MCEA 1951, Vol.1-5). In contrast to the Catholic schools, these pro-Communist schools were more ready to turn to the 5+1 system and

the Hong Kong textbooks (MCEA 1966, Vol.25).

In short, in the early 1960s, all Hong Kong Chinese-medium schools changed to the 5+1 system and local Hong Kong textbooks became popular. Such change had political roots. However, mathematics curricula in Macao were not strongly affected. Pre-war textbooks remained popular among the Chinese-medium schools in Macao, most of which were run by the Catholic Church.

Further Diversification: The Modern Mathematics Movement

The difference between the pre-war and post-war traditional textbooks was small because both had adopted the so-called pre-1800 model (Cooper 1985, p.54). This traditional approach was not severely challenged until the upheaval of the worldwide Modern Mathematics movement in the late 1950s. This movement suggested that the traditional separate approach did not adequately reflect the nature of mathematics. Unity of different mathematics concepts was emphasised: Plane and Solid Geometry were integrated into a single course; Trigonometry was merged with Advanced Algebra; and deductive methods, the processes of searching for patterns, and structural concepts like sets, relations and functions were introduced (Fey 1978, pp.340-341).

Although decision-makers in different countries had different motives, much of the movement originated in the USA. The news in 1957 that the Russians had been the first to launch an artificial satellite, the Sputnik One, was one of the most important ignition points. Many Americans believed that in order to restore the status of their country, the education of scientists and technologists had to be modernised. Mathematics was considered to need particularly urgent attention, and large sums of federal government money became available for innovation (van der Blij et al. 1981, p.111).

The American movement inspired curriculum developers in countries as diverse as Hungary, Indonesia, Nigeria, France, Denmark and Sweden (Moon 1986; R. Morris 1981; Morris & Arora 1992). The influence was also felt in the United Kingdom, though many reforms there in the 1960s also had local roots (Cooper 1985; Howson 1978). Of course, some countries did not follow the trend. They included China (K.T. Leung 1980, p.45) and Italy (Castelnuovo 1989, p.52).

In the mid-1970s, the cry of 'back to basics' in the USA led to decline of the movement. Through experience, people found that the impact of the movement was disastrous. Teachers did not understand what was expected of them, and students were lost in a maze of abstractions and fancy notations. Many textbooks had reduced set theory to lists of manipulations of unions and intersections that were quite as pointless as the worst pages of Algebra in the traditional textbooks. Disillusion in the USA was paralleled by, and to some extent the cause of, disillusion in many other countries. Some educators reverted to traditional mathematics, others used traditional books to supplement the modern ones, and yet others sought an amalgamated approach.

The Modern Mathematics movement was introduced into Hong Kong in 1964, and led to a new Certificate Examination syllabus for secondary Form 5 students in 1969. The new topics included mathematical induction, logic, matrices and determinants, bases for integers, flow charts, three-dimensional coordinate geometry, transformation, symmetry, networks, three-dimensional figures, and groups and linear programming (Siu Chan et al. 1997, Unit 4). In the early 1970s, about half of the

schools in Hong Kong, including Anglo-Chinese and Chinese-middle, had adopted the Modern Mathematics syllabus (Brimer & Griffin 1985, p.7). In 1980, in order to overcome the problems of the failure of the movement, an amalgamated syllabus attempted to bring together the strengths of both traditional and modern approaches. Some of the Modern Mathematics topics and much of the jargon had been cut. At the same time, the use of calculators was permitted in the public examination.

Educational organisations in Macao also felt the shockwave of the Sputnik One and the Modern Mathematics movement (MCEA 1957, 1974, 1979), but their response was mild. Traditional textbooks and separate approach had never been completely abandoned in Chinese-medium schools. Most of these schools updated their content knowledge by devising a subtopic called set and logic at senior levels. A few schools had experimented with the Hong Kong modern textbooks for a few years and turned back to the traditional textbooks. Even in the late 1990s, amalgamated textbooks remained unpopular among the Chinese-medium schools.

The situation of the English-medium schools in Macao was quite similar to that of the Chinese-medium schools. A few English-medium schools joined the Modern Mathematics movement by adopting the Hong Kong Modern Mathematics textbooks; and these schools also turned to the Hong Kong amalgamated textbooks after the failure of the movement. The majority did not abandon the UK traditional textbooks until the late 1980s. The reason for them to turn to the Hong Kong amalgamated textbooks was not pedagogical but pragmatic, due to the extinction of these pre-war UK textbooks in Macao. Portuguese-medium schools in Macao adopted the Portuguese Modern Curriculum in the early 1970s, and did not change to the amalgamated curriculum until the early 1990s (Ponte et al. 1994, p.348).

In sum, the rise and fall of the worldwide Modern Mathematics movement provided a chance for local mathematics educators in Hong Kong to establish their local textbooks and curriculum. Although vestiges of UK and USA influences can still be identified, local elements have been incorporated into the curriculum and textbooks. None of the Chinese-medium schools and few of the English-medium schools in Macao were changed by the movement, and they therefore were left behind by their counterparts in Hong Kong in the early 1980s.

Different Responses to Challenges in the Late Colonial Period

During the 1970s, 1980s and 1990s, both Hong Kong and Macao experienced rapid economic, social and political development. This fact, together with the global advancement of computers and information technology, caused mathematics educators in both places to reconsider their curricula. On the one hand, they had to identify international trends and catch up with them; and on the other hand, they had to deal with local problems. Again, due to socio-historical patterns and different perceptions of mathematics educators in both places, the responses to these challenges differed.

Nine-year universal, free and compulsory education had been implemented in Hong Kong since 1978, and by the 1990 the retention rate in secondary Form 5 exceeded 90 per cent. Further, with the rapid expansion of tertiary education, most Form 5 graduates could proceed to further study. Individual differences in capability and aptitude became an increasingly important issue after the early 1990s. The examination syllabuses of the two well-established Advanced Level subjects, Pure

Mathematics and Applied Mathematics, were trimmed. Furthermore, two less-demanding Advanced Supplementary subjects, Applied Mathematics and Mathematics & Statistics were introduced in 1994. With these changes, the mathematics curricula at the matriculation level could more easily benefit both science and arts students.

The secondary Mathematics and Additional Mathematics curricula did not change significantly from the late 1970s to the 1980s. Only in the early 1990s was a holistic review of the mathematics curriculum urged by local mathematics educators. A new secondary mathematics curriculum was proposed with a more balanced emphasis on process and content. It was also intended to take into consideration social and technological changes; have more balanced consideration of both science and arts students; and have more balanced emphasis on the cognitive and affective development of the students (Siu Chan et al. 1997, Unit 4).

Mathematics curriculum development in Macao was uncoordinated when compared with Hong Kong. Eclectic approaches were adopted by most Macao schools when challenged by the rapid social, economic, political and technological changes. By the late 1980s, the traditional mathematics textbooks had become obsolete. The content knowledge was on the one hand too demanding for the majority, and on the other hand too remote from an information age. Some Catholic and Protestant Chinese-medium schools tried to replace the traditional textbooks by the new Hong Kong textbooks, but most of them turned back to the traditional textbooks in the early 1990s. The incompatibility between the Hong Kong 5+2 system with its own public examinations and the 3+3 Taiwan system with the Macao Taiwan university entrance examination was one of the main reasons for their failure.

Unlike the Christian schools, the pro-Communist schools had a more coordinated and successful reform. In 1987, the year of the Sino-Portuguese Joint Declaration, these schools turned from the Hong Kong Chinese-middle 5+1 system to the PRC 3+3 system. By the early 1990s, most of these schools had adopted the PRC textbooks. The compatibility between the PRC textbooks and the examination syllabus of the PRC university entrance examination for Macao students was one of the main reasons for successful reform. Yet although the new PRC textbooks were less problematic than the traditional Hong Kong textbooks, the curriculum was still too demanding and out of touch with modern technology (Siu Chan et al. 1997, Unit 3).

As mentioned above, the situation of the English-medium schools in Macao was quite problematic. The majority only turned to the new Hong Kong textbooks in the late 1980s because of the extinction of the pre-war UK textbooks. However, many teachers still supplemented the new Hong Kong textbooks with the old UK Algebra textbooks. This combined use of traditional and new textbooks reflected their traditional views on mathematics teaching and learning. The Portuguese-medium schools were in a better position because they followed the mathematics curriculum reform in Portugal in the early 1990s. The new curriculum had been designed by considering the impact of universal education and technological advancement. Most mathematics teachers in Macao Portuguese-medium schools welcomed this reform.

Before the 1984 Sino-British Joint Declaration and the return of Hong Kong to Chinese sovereignty in 1997, the curriculum development machinery in Hong Kong had been gradually built and had gained its own momentum for further development. The Curriculum Development Committee (CDC) was formed in 1972 in response to the introduction of compulsory primary education. Teachers were appointed to the mathematics subcommittee to advise on preparation of the teaching syllabuses.

Examination syllabuses were produced by a mathematics subcommittee of the Hong Kong Examinations Authority (HKEA). Both the CDC teaching syllabuses and the HKEA examination syllabuses heavily shaped the implemented mathematics curriculum. Since the reorganisation and renaming of the Curriculum Development Committee to Curriculum Development Council in 1988, together with the establishment of the Curriculum Development Institute (CDI) in 1992, many curriculum innovations have been brought into the development of mathematics curriculum. These have included the school-based curriculum development, core curriculum tailored syllabus, and the Target Oriented Curriculum.

Curriculum development organisation in Macao appeared immature when compared with Hong Kong. The Macao government only embarked on an active role in curriculum development in 1994. Curriculum development committees for different subjects were formed, with membership including teachers from both official and private schools and from the University of Macau. Provisional teaching syllabuses for different subjects at different levels were drafted by referring to the PRC, Taiwan and Hong Kong models. Although the provisional primary, junior and senior secondary mathematics syllabuses were written to face the new challenges and were launched in the Luso-Chinese schools in 1995/96, the Macao government had great difficulty in persuading the private schools to adopt these syllabuses (K.C. Tang 1999).

In summary, mathematics curriculum development was more coordinated in Hong Kong than in Macao. Mathematics educators in Hong Kong were involved quite actively within the organisational framework, and curriculum innovations were vigorous. In contrast, mathematics curriculum development in Macao was uncoordinated. An eclectic approach was adopted by most schools, and political influence was significant even in this relatively value-neutral subject.

Postcolonial Initiatives: Converging Goals and Diverging Paths

The reversion of sovereignty in Hong Kong and Macao in 1997 and 1999 respectively added fuel to the curriculum reform engines. In Hong Kong, immediately after the transition an ad hoc committee was set up under the Curriculum Development Council to review the mathematics curriculum. The committee was asked to recommend ways to enhance intra-level coherence in the curriculum at various levels, based on sound academic principles and practical demands. In 1998, at the request of the committee, the Education Department commissioned two studies to provide inputs. One report (Curriculum Development Council 1999a) presented the views of students, parents, teachers, university lecturers, curriculum planners and human resources personnel in the commercial sector. The other report (Curriculum Development Council 1999b) analysed mathematics curricula in major Asian and Western countries. The final report (Curriculum Development Council 2000a) presented an overview. The work formed the foundation of several detailed curriculum documents, including the syllabuses for secondary mathematics, primary mathematics, and secondary additional mathematics (Curriculum Development Council 1999c, 2000b, 2001b).

Restricted by the small-state constraints (Bray 1992c; Tang & Ngan 2002), the immature curriculum development organisation in Macaohad few material and human resources compared with Hong Kong. Partly because of this, provisional teaching syllabuses for junior and senior mathematics were drafted by referring to the PRC,

Taiwan and Hong Kong models without the support of local research. These syllabuses were tried out by several Luso-Chinese secondary schools, and the Macao government then invited local, Hong Kong and PRC mathematics educators to study the design and implementation of these provisional syllabuses. Finalised syllabuses were then published just a few months before the return of sovereignty (Macao, Department of Education & Youth 1999a, 1999b, 1999c).

The syllabuses in Hong Kong and Macao had significant similarities. Their aims, contents, proposed teaching methods and assessment strategies were all in line with the international trend identified by Niss (1996). This included contribution to technological and socio-economic development, contribution to cultural maintenance and development, and provision of prerequisites to help learners to cope with modern society. At the level of classroom teaching and learning, international trends emphasised mathematical thinking and creativity, personality development, mathematics in society and culture, and information technology in relation to mathematics.

This analysis shows that the mathematics curricula in Hong Kong and Macao were converging at the documentary level. This was especially evident at the junior secondary syllabus, because Macao explicitly abandoned the traditional approach by integrating algebra, geometry, analytical geometry, trigonometry, probability and statistics, and by adopting the spiral approach of content organisation (Macao, Department of Education & Youth 1999b, pp.3-6).

The convergence of educational goals in Hong Kong and Macao, together with other East Asian countries such as Singapore, reflected the strong impact of globalisation and the advent of the knowledge economy dominated by the West (Sharpe & Gopinathan 2002). However, in order to understand the stability and change of school knowledge, local socio-historical background and efforts of local mathematics educators should also be considered. Tang and Bray (2000), adopting the analytical framework proposed by Archer (1979, 1993), charted the emergence and development of the centralised and decentralised education systems in Hong Kong and Macao respectively. The structural properties of these two different systems were shown to be key factors conditioning the changing paths of these two places.

The nature of divergence within convergence may be identified by study of the implementation of the new syllabuses. The Hong Kong secondary syllabus (Curriculum Development Council 1999c) was launched in secondary Form 1 in 2001. The list of recommended textbooks again demonstrated the power of centralist forces. Although other factors encouraged the use of school-based materials, and although teachers were encouraged to exercise professional judgement in preparing and choosing learning materials, the Hong Kong Certificate of Education Examination constrained teachers from moving far from the official syllabus.

In Macao, implementation of official syllabuses was much less systematic. This was partly because of the lack of a centralised school-leaving examination. It also reflected the lack of locally-published textbooks, and the government's unwillingness to force unification of approaches by the Catholic, Protestant and pro-Communist schools. In other words, Macao's major implementation obstacles were at the system or administration level.

In 2000, a four-year mathematics curriculum experimentation programme was launched to tackle with this problem. One Protestant school, one Catholic school and two official Luso-Chinese schools were invited to join this programme. With the

academic and professional support from Beijing Normal University, mathematics teachers from these schools attended workshops and visited schools in Beijing. They were also given mentors from Beijing for on-site training and consultation in Macao.

This experiment certainly helped to bring the official Luso-Chinese and private Chinese-medium schools together for the adoption of the new mathematics syllabuses. However, the reform still encountered two major challenges. The first challenge was structural, and arose from the English-medium schools within the poly-centred decentralised system. Unlike the Portuguese schools which had been excluded from the government's financial umbrella since the reversion of sovereignty, most English-medium schools were part of the government-subsidised network. As a result, the mathematics curricula of these schools could not be ignored. Yet since the government appeared to have no plan to publish English versions of the syllabuses, the English-medium schools seemed destined to become abandoned children of the reform which could only passively follow the new Hong Kong syllabuses and use the new Hong Kong textbooks without systemic support for initiatives and innovations.

The second challenge was ideational, especially at junior level, and came from teachers and teacher-educators (K.C. Tang 1999). As mentioned above, the junior secondary syllabus explicitly abandoned the traditional approach by integrating the topics of algebra, geometry, analytical geometry, trigonometry, probability and statistics, and by adopting the spiral approach of content organisation (Macao, Department of Education & Youth 1999b, pp.3-6). In 2001, a basic competence assessment was conducted to assess the general achievement of secondary Form 3 students in Chinese, English and mathematics. Only algebra and geometry problems were included in the mathematics assessment paper, and questions on analytical geometry, trigonometry, probability and statistics were omitted (Macao, Department of Education & Youth 2001, Appendix). This appeared to indicate a failure of the junior mathematics reform launched in 1995/96.

In summary, in order to demonstrate the success of 'one country two systems', the Hong Kong and Macao governments worked hard on education reform projects around the period of reversion of sovereignty. In mathematics, the new syllabuses of both places were heavily influenced by international trends dominated by the West. A convergence of curriculum reform at document level was therefore observed. With the support of a centralised system and its structural and administrative tools, the Hong Kong government gained success at system level, though many challenges remained at school, classroom, teacher and student levels. Conditioned by the poly-centred history and the decentralised system, the Macao government was challenged at an early stage at system level. PRC influences on Chinese-medium schools, and Hong Kong influences on English-medium schools, remained significant. Divergent curriculum reform was therefore observed at implementation level.

Conclusion

This historical and comparative analysis of the stability and change of secondary school mathematics curriculum in Hong Kong and Macao shows that strong commonalities existed in the 1920s. Although colonial influence was significant in English-medium and Portuguese-medium schools, influence from the Republic of China was dominant in the Chinese-medium schools.

The nature of this external influence changed abruptly after the success of the Chinese Communists in 1949. For the Chinese-medium schools in Hong Kong and Macao, the difference in response of the two colonial governments to this change marked the point of bifurcation for the mathematics curricula in the early 1960s. At the same time, the worldwide Modern Mathematics movement gained momentum and a sweeping influence in Hong Kong. Local mathematics educators were involved in this development, and the colonial government played a less significant role. Mathematics curricula for both Chinese-medium and English-medium schools were affected. Mathematics educators in Macao were less willing to change, and major reform could only be found in the Portuguese-medium school due to the reaction of local mathematics educators in Portugal rather than in Macao. Most of the Chinese-medium and English-medium schools in Macao were only slightly affected by this worldwide movement.

The introduction of nine-year compulsory free education in Hong Kong in the late 1970s in Hong Kong reinforced this loose tie between colonial government and local mathematics educators. Curriculum development organisation was adjusted further in the early 1990s in order to face different internal and external challenges. Macao also started to develop its curriculum development organisations, but faced continuing systemic challenges. Macao's idiosyncratic socio-historical background and its vulnerability to PRC influence were the two main forces pushing it to a very different curriculum track from that of Hong Kong. In short, external influences on these two places have always been similar, but local socio-historical background and efforts of local mathematics educators have caused differences.

At a conceptual level, understanding of patterns can be facilitated by noting the interests and values attached to curricular arrangements. Researchers such as Cooper (1985), Moon (1986) and Stanic (1987a, 1987b) have observed that that the ways in which school knowledge is selected, organised and assessed are partly determined by the distribution of power. The sociological assumption is that the most important and overt relation between the organisation of curriculum knowledge and the dominant institutional order will be reflected in social stratification. If changes threaten power structures, resistance will be encountered.

Archer (1983, 1993) pointed out that theories about cultural transmission and reproduction tend to neglect education systems. Without incorporating different elements and structures of the educational systems for different countries or places, the theories cannot account for all the variances in stability and change in educational practice. Archer's Morphogenetic Systems Theory provides a useful tool for analysis of Hong Kong and Macao as well as other parts of the world.