Mathematics at two schools, one Australian, the other Japanese, both located in Australia: their Philosophies and Practices

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This paper contains observations of the mathematics curriculum in action of two schools, one Australian and one Japanese, both situated in Victoria, Australia. While school structure and mathematical content in both schools were substantially similar, there were notable differences, for example, continuous school based and government testing in the Australian school compared with the relatively few but highly significant examinations set by Japanese institutions as student entrance requirements. Permeating these differences were divergent mathematical histories, and social and cultural factors in the two countries.

Emphasis placed on the skills of mathematical and related scientific and technological fields in its national education system has been recognised as one of the major contributing factors to the superior commercial and technological expertise reached by Japan with astonishing speed after the Second World War. The introduction of an American education system after the War perhaps may have resulted in the development in Japan of a school education similar to that of Australia which, in its own education system, used ideas largely from Great Britain and America. This study attempted to interpret differences and similarities observed in the mathematics programs of the two schools in terms of the values governing the historical development of mathematical knowledge and social and cultural factors existing in Australia and Japan. The content of this paper is derived from the observer's Masters Project (Wotley, 1993).

Some Historical and Cultural Perspectives

Japan is the only country where oriental mathematics continued undisturbed by outside influence for a long period of time.This can be attributed to the virtual sealing off of its boundaries in the 16th century after the execution of Jesuit missionaries who had converted some of the Japanese population to Christianity. Even China, which had contributed the ancient foundations of mathematical thought in Japan, was excluded (Spence, 1985). Japanese mathematicians were secretive and mathematical treatises were passed on to star pupils and eldest sons. This may have been due to the relegation of mathematics to commercial activities by the noble Samurai class who held it in some contempt. It is recognised Confucianism which spread from China to the East Asian countries 2500 years ago exerted a major influence which continues today. Its values include diligence and harmony in the workplace, strong family ties, and a passion for education (Adam Smith, 1988). The tenets of Taoism were also influential. They included the belief that there was an inherent self-sufficient order in nature and there were few regularities in the "mundane sphere" to which mathematics could be profitably applied.(Needham, 1956). By the 18th century mathematics had arrived at practical application. Japanese mathematicians who were adept at the solution of higher degree equations before the West, did not access Calculus, which revolutionized 17th century mathematics and science in Europe. Instead, the Japanese used Infinite series in meticulous and exhaustive calculations in attempting to find the formula of the circle theoretically (Yenri), much of which was applied to packing problems involving spheres. Smith and Mikami (1914) liken early Japanese mathematics to the execution of a red lacquer box which required exquisite work, minuteness, patience and everlasting pains. When Japan's isolation was ended in the 19th century its scholars still considered this quality of "minuteness" to be superior but this did not prevent the acceptance of Western ideas in Japan (Needham, 1956). In the latter part of the 20th century at the end of World War 2 when Japan was occupied by the allied powers, the American school system was established with its curriculum content and physical environment. While Japanese schools appeared to accept this system, in reality, they evolved differently (Rohlen, 1983), (Howson, 1991). Balanced with the American ideals of individualism and democracy

were the ideals of Confucianism and the prewar elitist system of education, none of which entirely dominated the resulting educational system. Today's Japanese national school curriculum is an amalgam of these influences.

Australia's colonial history which had close ties with Anglo-Celtic ideals looked early to the universities of Great Britain for its school mathematical structures and curriculum. Australia's Western heritage rather than its geography, turned its interest firmly in the direction of Europe and America and its school mathematics throughout most of the twentieth century reflects this connection. In the latter part of the twentieth century new structures and curriculum have some Australian character. Whether this is a recognition of the diversity of its population today (it now has the second most diverse population in the world) is a matter for further investigation. While all states in the country have similar patterns of history and social organisation, there is no national curriculum and a number of different procedures operate in the state education systems.

Two Schools in Australia

School A is an Australian school (years K - 12) designated as an Independent School. Within the largely homogeneous cohort of Australian students of Anglo-Celtic origin at School A, Japanese students constitute about 5% of the total population of the school. Most Japanese students attend School A for approximately 4 years. The progress of these students through school, while of interest, proved to be very difficult to track in practical terms because of continuous arrivals and departures often during term time.

School B is also an Independent or Private School (years K - 9) owned by a Japanese consortium. Ostensibly it provides a continuity of education for children of Japanese professional men appointed to positions in Australia. Employing teachers imported from Japan on a contract basis, it administers the Japanese National Curriculum using imported texts and materials designed for that curriculum.

Communication with Japanese mathematics teachers in School B who had limited English skills, and the lack of Japanese language skills of the writer, did not preclude useful exchange of materials and discussion. A limited amount of translation was available.The international notation used in texts allowed understanding of material printed both in Japanese and English.

Observations of Practice

Are there differences in general structures?

School A has a structure common to the majority of schools in Victoria. School B is the common model in Japan but student numbers at each level and in each classroom are smaller because of its location in Australia. Table 1 summarizes the major features of these structures in the two countries.

Table 1: General School Structures Japan	Australia (State of Victoria)
Elementary School - Years K-6 Lower Secondary School Years 7 -9 Upper Secondary School Years 10-12	Primary School - Years K-6 Secondary School - Years 7-12
Attendance at Upper Secondary level is not compulsory. 94% students proceed further.	A minority of students leave at the end of Year 10. Majority of students proceed further.
National Curriculum defines school programs.	Schools based programs in years K-10. Vic Board of Studies administers the VCE (Vic Certificate of Education) in Years 11-12
Written examinations set by Senior High Schools or Provincial Prefectures and Universities as entrance exams at the end of years 9 and 12 levels.	Continuous school based testing together with government diagnostic testing during Years K-10. Combinations of VCE results used for entrance into higher institutions and universities.

How comparable were the hours of teaching?

In the year observed(1993) the Japanese school day was approximately 8 hours compared with a 7 hour day in the Australian school. The Japanese school year was 187 days which was less than the average of 240 days for Japanese schools in Japan. The time spent in school however still exceeded the Australian times (180 days) and this added to the longer school day meant that the Japanese students had more face-to-face teaching than the Australian students. Vacation periods in the two schools bore little resemblance to each other. The four term structure punctuated by three fortnightly breaks and a longer break during summer in the Australian school differed greatly from the two concurrent half-yearly semesters and one long break of the Japanese school.

In contrast to the student situation, Japanese teachers did not spend proportionately as much time in face-to-face teaching as the Australian teachers. The proportion of preparation time in the allotment of the Japanese teachers was significantly greater.

What were the main features of teaching material?

Japanese National Curriculum texts issued to students were small compact books which contained mainly collections of examples. Within each book a small selection of single topic areas were covered. Several of the text books were issued during the year. They were used by students for practice and homework. It was interesting to note that illustrations in the small Japanese texts contained some photographs of Japanese children of the relevant age participating in activities and small cartoon figures drawn in a very simple way. The figures invariably wore cheerful expressions and were interspersed among problems and indexes. These features, combined with the small size of these books with brightly coloured covers contributed a certain "user friendliness" in the Japanese texts up to Year 9 level. They could not easily be used for self teaching purposes. The Japanese teacher had a central role in introducing and discussing topics and arrived in the classroom with extensive amounts of material prepared before its commencement.

The Australian texts were large, cumbersome, soft-covered volumes which contained enough work to fill the whole year. A text appropriate for each level was chosen by the Mathematics Department of the school from a wide range of commercially available material. Each student purchased a copy for use throughout the year. "User friendliness" seemed to be missing from these heavy, unavoidably dog-eared texts. To a certain extent, these books could be seen as self teaching as they contained instructions, worked examples and further examples for practice usually graded in increasing levels of difficulty. This self teaching nature of the Australian texts allowed individual students to move ahead of the class sometimes to another topic or to extension exercises usually provided at the end of the book. Some teachers tended to follow texts closely, using them as aids.While teachers did prepare other materials it was possible for a teacher to enter the classroom with little preparation and to closely follow the text in teaching a topic which was quite different from previous topics.

What teaching strategies were used in the classroom?

While the Japanese class lessons were highly structured and teacher centred, much discussion between teacher and individual students or groups of students preceded arrival at and application of a concept. The Australian classroom had less reliance placed on the teacher, the text serving as instruction as well as practice and therefore allowing more individual student progress. The Australian school also used techniques of setting or streaming over a year level in years 7 -10 whereby students were grouped very broadly into achievement level groups over a year level. Within these groups there were differences in pace and the use of extension exercises for higher achievers. Exercises were modified for lower achievers. Students were able to move between levels if testing procedures indicated changed levels of understanding. In the Japanese school at levels up to year 9, classes were of mixed ability. Unfortunately while many students in the Japanese class were involved in discussion, language difficulties prevented the observer from gaining a true understanding of the quality of their contributions.

In keeping with the practice of moving from one book to the next during the year, Japanese texts lacked revision exercises. Once a topic was taught thoroughly it did not

reappear. This was in contrast to the constant reappearance of a topic in increasing difficulty over successive year levels in the Australian School. For example, Linear Graphs and Equations as a topic appeared in Year 8 only in the Japanese school but was treated in sections over 4 years in the Australian school. Table 2 illustrates this contrast.

Table 2: Linear Graphs/Equations

Japanese School (from text of Japanese National Curriculum)	**Australian School** (from syllabus documents of teachers at different levels of the school)
Year 8	Year 7
• Practical examples, tables of values, plotting points	•Plotting Points, using Cartesian grids
	Year 8
• y =ax + b, transformations altering a and b.	•Algebraic solution of linear equations and inequations
•gradients and intercepts, restricting domain and range	$x + 9 = 15$ (at first using the technique of filling in gaps)
	$3x < 21$
•applied problems using tables of readings, plots	$x + 5 > 13$
	$3x + 7 = 25$
•ax + by = c and y = mx +c	$\frac{3x}{4} + 13 = -31$
	$3(x + 7) = 4(x + 9)$
•graphical solution of simultaneous linear equations.	$9 + 6(x - 7) > 5x$
	$\frac{8x - 3}{4} = 7$
•Linear programming	
	Problems using linear equations.
•solving inequations eg $x - 8 > 3x$ $3x + 2 < 20$ $6x - 1 < 3(4x + 1)$ including use of number lines for simultaneous inequations.	Year 9
	Graphs using intercepts, points and gradients, y = mx + c Graphing inequations Simultaneous equations
	Year 10
	Plotting, sketch graphs, linear modelling, equations and inequations, problem solving eg fixed and variable costs, lines of best fit.

The number of topics studied in a half-yearly period in the Japanese school exceeded that of the Australian School as illustrated in Table 3. The problem solving time listed in the Australian School syllabus was not aligned to topics in the course. Problems were designed to encourage creativity through the exploration of different ways of solving number puzzles, spatial types of exercises and everyday life situations such as traffic survey, factory production. Students usually worked in groups for these exercises and different interpretations sometimes resulted in different answers. Shorter hours of face-to-face teaching in the Australian School and the time set aside for problem solving exercises contributed to the smaller number of skill-based topics covered by the Australian School.

Table 3: **Japanese School** **Year 8 (1 semester)**	**Australian School** **Year 8 (1 semester)**
1. Algebraic simplifications - collection of like terms including use of positive and negative numbers , use of brackets, including indices and fractions, all operations, applied examples. 2. Co-ordinate pairs, techniques of algebraic solution of linear and simultaneous equations. 3. Linear equations and Graphs including simultaneous equations. 4. Inequalities - algebraic solutions of inequations. 5. Straight line geometry, transformations, similar and congruent triangles. 6. Geometry Theorems and proofs, triangle and quadrilateral geometry. 7. Applied problems using similarity and congruence with various polygons 8. Statistics, bar graphs, frequency polygons, frequency tables, using intervals of measurement, mean, grouping data (2 pages at the back of the book give calculator instruction) •Total number of chapters = 8 approximately depending on how overlap of some chapters is considered.	1. Directed number - introduction of all operations, applied problems 2. Algebra - collecting like terms, multiplication by an integer, multiplication and division with pronumerals, building up symbolic expressions, the Distributive Law. 3. Measurement - perimeter and circumference, area of simple and complex shapes, area of parallelogram and trapezium, area of circle and annuli, volume of prism. 4. Statistics - Interpretation of graphs, bar, pie and other pictorial graphs 5. Equations and Inequations using algebraic solutions. There were 3 problem solving sessions built into the semester which use about 6 to 7 hours of class time during the semester. •Total number of topics = 5. in addition to 6-7 hours of problem solving activity spread throughout the semester.

Assessments - at what stage did they occur and for what purposes?

As can be seen from Table 2 the major concepts of linear equations and graphs were taught at an earlier stage in the Japanese curriculum. This characteristic is consistent throughout all levels and can be equally illustrated in the areas of arithmetic skills at Primary level. In general, at the secondary level, the Japanese students operated at a skill-based standard about two years ahead of the Australian students.

Assessment observed in the Australian School occurred about three times in the term usually at the end of each topic and these results were tabled four times in the year, and an average result together with teacher comment was sent home to the parents on each of these occasions. Formal examinations commenced at year 10 level. Government-based diagnostic testing is currently in the process of introduction into schools over K - 10 levels At year 11 level (in some cases year 10) the two year VCE is commenced. This has 2 assessment pathways : one which stipulates that the Work Requirements of each study taken by a student
must be fulfilled and the other is an achievement mark allocated to the combination of various parts of the study (Common Assessment Tasks or CATs) which may be

examination testing, presentation of a project, fulfilment of practical aspects etc. Student scores are arrived at through various combinations of these marks and the results of a General Achievement Test (GAT). Scores are used by Universities and Higher Institutions as entrance qualifications.

Since the Japanese school operated up to year 9 level only, the assessment patterns of the few Japanese students at VCE level in the Australian school were investigated. Table 4 records the.assessment pattern of the only Japanese student completing year 12 in 1992 in the Australian school.

Table 4 : VCE Results of a Japanese Student at the Australian School.

Student	CAT 1 - Project	CAT 2 Problem Solving	CAT 3 Facts and Skills Multiple choice exam	CAT 4 Analysis External Exam
Student X	C+	B+	B+	A

There was evidence, according to the experience of the mathematics teachers in the Australian school, that Japanese students in general found assignments and forms of assessment which were not directly skill based extremely difficult. In 1992, the Australian students who were checked on a random basis of every fourth student in an alphabetical list achieved better results in CAT 1 and CAT 2 than in CAT 3 and CAT 4 in the ratio 2.5 : 1. The numbers are far too low to draw fair conclusions but the pattern does support the anecdotal evidence of the teachers. Other factors and controls such as language skills would be necessary to test, as problem solving and project exercises often contain more words than the skill-based exercises.

In Japan, written examinations are set by universities at the end of year 12 and these are of paramount importance to teachers, parents and students. These examinations emerged as the driving force in the Japanese school where, in discussions about aims and objectives with teachers, success in preparing students was a pivotal objective. In both Australia and Japan a huge amount of attention is devoted to this level by teachers, students and parents. Competition is intense. A coaching industry in Japan addresses itself to placement of students in the institutions of their choice. Unlike Australian students however, Japanese students may sit again, sometimes in the same year, if they fail to qualify on their first attempt. In Victoria the the multiplicity of tasks in each study and a penalty system act as strong deterrents to second attempts.

The progress of mathematics students in the Australian school therefore seemed to be punctuated by a myriad of testing procedures of different types and at different times of the year which provided constant feedback to students, teachers and parents. In contrast examinations in the Japanese school were driven by entrance to institutions at two major focal points - entrance to Senior Secondary Schools at the end of Year 9 and entrance to Universities at the end of year 12.

Interpretation of the different mathematical pathways taken by the two schools: what impact did the Australian location of the Japanese school have on its mathematical program?

Differences were observed in the practice of both schools despite some similarity in mathematical content and structure. Interpretation of these differences could be made through linkages between them and the histories and cultural and social characteristics of Japan and Australia.

In the Japanese school the meticulous planning of lessons and the exhaustion of a whole topics in their entirety have echoes in the mathematics.of old Japan. The teacher centred classroom with all students taking part in mastering a concept has the familial ring of Confucianism which regards the school as a family where teachers have their own familial roles to play.(Rohlen, 1983). The text books which were addressed to the students age level through their graphic design reinforced the place of the student in the family as well as providing a volume of skill-based examples to be diligently completed. The Confucianist belief that the difficulty of the task is not significant in the child's level

of performance (Robitaille and Travers, 1991) means that poor performance is attributed to lack of effort. Assessment does not reinforce failure but is a screening device for movement to another level. Success is directly proportional to effort.

The multiplicity of testing observed in the Australian school perhaps resulted from the onslaught of constant change in school curriculum design in the last years of the twentieth century as Australia moves to a different identity.The lack of uniformity of mathematics teaching between states and schools within each state also may have played some part in this.

The striving for creativity and individual participation through problem solving activities are directions commonly followed in Western school mathematics. A belief in progress at an appropriate individual ability level also accounted for ability groupings at each level of the Australian school and the high frequency of diagnostic testing. However the effect of these activities, together with less teaching time in the classroom resulted in lower levels of skill in the Australian school, particularly in secondary levels.

Finally, did the Japanese school located on "alien soil" adopt any of the mathematical philosophies or practices of mathematics schooling in Australia? Did interchange take place with the Australian school which had in its own cohort of Japanese students living in Australia for the same reasons as those in the Japanese school.? Were any general characteristics of Australian education applied in the Japanese school? No evidence of this was observed. The Japanese school's semester dates and time schedules, in particular, indicated its separate existence as did its wholly imported teaching staff and curriculum materials. No non-Japanese students attended the school at the time of observation. While the writer found the Japanese staff helpful and friendly and text materials were generously provided, virtually no elements of Australian school mathematics policy were observed in the practices.of the Japanese school.

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