AN EXPLORATION OF THE DIFFERENT STRUCTURE OF THE MATHEMATICS REGISTER IN ENGLISH AND ASIAN LANGUAGES: SOME CONSEQUENCES FOR THE TEACHING OF ESL IN PREPARATORY PROGRAMMES.

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This study investigates the linguistic problems ESL post-secondary students have when communicating through the content area of mathematics. The majority of these students have the mathematics register in their own tongue but need to transfer this to English so they can communicate effectively in tutorials, lectures, practicals and assignments.

To investigate these linguistic problems, students from a pre-tertiary (UNIPREP) course were interviewed and their mathematics pretests and the problems from mathematics vocabulary tests were analysed.

Findings from the pretests suggest there are a number of levels of understanding and types of methods used by students in solving the problem. The results of the vocabulary study outline the frequency of occurrence of the types of mistakes students make. Preliminary findings from student interviews and research suggest that while some of the mathematics learnt through their native tongue is easily translatable into English other features are more complex and further research needs to be undertaken in this area. The overall results of this paper clarify the problems faced by ESL students and can be used for ESL educators in their curriculum design and assessment.

Non-English speaking overseas students undertaking tertiary studies in English speaking Universities may have what is described as cognitive academic language proficiency (CALP) (Cummins, in Dale and Cuevas 1987) in their native tongue, but do not possess this in English. Moreover, they may have the English skills to communicate effectively for social purposes, but when they are faced with precise academic language, their ability to communicate effectively is reduced.

In mathematics, which is rich in cognitive academic language, students may have the language skills in their native tongue but there are translation difficulties due to the precise nature of the mathematics language (i.e. the mathematics register). It is not just the individual words in mathematics, but the semantic, syntactic and pragmatic features which create problems for the ESL student (Spanos, Rhodes, Dale and Crandall, 1991). ESL students' level of mathematical thinking may help to overcome some of the linguistic problems. These have been categorised by Kessler (1987) (from Schoenfeld (1985)): (i) the cognitive resources students already have, (ii) the heuristics the students use to help solve the problems (iii) the control processes or metacognitive resources students may be able to utilise and (iv) the belief systems students bring with them.

Much research has been conducted in primary and secondary education in the areas of language and mathematics for ESL students (McGregor 1990, Cuevas 1984, Dale and Cuevas 1987). However, limited research has been conducted in the area of post-secondary education. For the majority of students who have the mathematics register in their own tongue, the problem is to develop their abilities to the extent that they can communicate effectively in tutorials, lectures, practicals and assignments.

This topic will investigate the problems ESL students have and the thinking students use to overcome the problem when communicating through the content area of mathematics. This includes an investigation into some of the typology of the mathematics language i.e. a comparison of the mathematics register in English and other Asian languages (Chinese, Korean and Japanese). The data were collected through (A) interviews (B) pretest results and(C) vocabulary quiz mistakes.

THE SUBJECTS

All students used in the testing were overseas students who had either completed an ELICOS programme at university or had an equivalent English standard, and were enrolled in a preparatory programme.

THE INSTRUMENTS

The 1993, 13 Semester 1 ESL students sat for a pretest (designed to identify the mathematical mastery of any prospective student). Students were asked to circle words or phrases that they did not understand. As well some students were interviewed on their maths pretest ensuring a more complete picture of the linguistic difficulties. Students must pass nine vocabulary and mathematics mastery quizzes during the semester (Arithmetic (3), Algebra (2), and (1 each) Measurement, Graphing, Probability and Statistics). Each student sits with the tutor when the quizzes are marked and the student is expected to talk through each problem with the tutor. This process, together with extensive individual interviewing with a Korean, a Tiawanese and a Japanese student clarified the extent of the linguistic transfer difficulties. As well, the most common mistakes on the vocabulary quizzes for the previous three semesters were summarised.

THE RESULTS

For the pretest (See Appendix A) each question for each student was analysed and categorised thus:

		ENGLISH	
		UNDERSTOOD	NOT UNDERSTOOD
MATHS	INCORRECT	E_uM_i	E_nM_i*
	CORRECT	E_uM_c	E_nM_c

*some students picked up the right cues but the maths was incorrect; others picked the wrong cues and the maths was correct.

A number of questions from the test can be used to exemplify the mathematics register categories used by Spanos et. al. (1991) and the mathematical thinking processes outlined by Kessler (1987).

While generally students were able to solve questions involving syntax such as 4d (Appendix 1), they had more problems with the Semitics, e.g. where new meanings were placed on words like 'rounding', 'subject' and 'sum of'. Students also displayed lack of cognitive resources e.g. in Q9 and 11b the concept was new and in Q3 and 10b the process had been forgotten.

If students had the cognitive resources, then questions such as 2d posed few problems. If they didn't know the word "simplify" or "ratio", but understood the symbol 24:14, they knew its alternative form was 12:7. However, using these mathematical heuristics for problem 1f led students to give the exact arithmetic answer. However, to solve the problem they must understand the word 'estimate' and probably 'rounding'. For ESL students with an ordinary translation dictionary this would not be difficult since estimate is a natural word and rounding usually has a mathematical translation in the dictionary. Question 5b. poses more problems since knowing 'rearrange' and 'formula' sometimes gives a solution $3 + y - 5x - 4 = 0$. Although some metacogintive "control" process intuitively allow students to rearrange the formula a specific knowledge of "x...the subject" is usually necessary.

The pragmatic and discourse features of the mathematics could be found in the last part of question 11b but as students did not understand scattergram, parts (ii) and (iii) were generally not attempted. Students who did attempt part (b) took the cues from the data and attempted to draw a column or a trend graph.

The vocabulary tests completed by the students emphasised the common problems faced by ESL students. These could be divided into 10 main types (Table 1). Given the nature of their languages, this would be expected. For example, it is possible to say the phrase 3 x 7 in Chinese, Japanese and Korean in more than one way, but in Mathematics it is usually expressed one way only. While there is extensive use of prepositions in these languages it is not as common in mathematics. For example in Japanese they may say Ju o ni de waru (10 with two divide) it is more common to say Ju waru ni (10 divide two). In Mandarin they usually say 7 gen 4 (7 take 4) not 4 bay 7 gen (4 is from 7 take). Mandarin especially does not have plurals or suffixes, tenses, or conjugations and sometimes does not use verbs (see Newnham 1987). Hence the large proportion of mistakes seen in the vocabulary tests. Some interesting findings from the interviews with students include the literal translation of the vocabulary. While our derivation of the word parabola, quadrilateral or rhombus come from Greek morphemes or roots, their meaning is not widely known, but the word throw something up, four corner shape or stage shape conveys a meaning. In scientific language this is more dramatic - a sphygmomanometer would be much better described as a blood pressure calculator as is the Chinese translation. A general detailed analysis of the typology of Mandarin can be found in Li and Thompson (1981) and a more detailed analysis in the mathematical field is currently being investigated.

TABLE 1: MOST COMMON MISTAKES ON VOCABULARY TESTS

	percent of all errors
(i) not putting the correct ending on the word, e.g. equal(s), round(ed), fifth(s), factor(s);	24%
(ii) not putting the correct preposition and the ending, e.g. multipli(ed by) , add(ed to);	23%
(iii) not including the preposition of, e.g. inverse (of), likelihood (of), square root (of)	5%
(iv) misuse of the preposition in, as, on, with, etc.;	5%
(v) misplacement of words eg for $-\sqrt{2}$ or $\sqrt{-2}$;	4%
(vi) misuse of the articles 'the' and 'a';	8%
(vii) problem with comparasion, e.g. as big as; is greater than;	10%
(viii) new technical vocabulary;	9%
(ix) discourse features, e.g. describing power; statements with brackets;	9%*
(x) saying numbers correctly, e.g. seven hundred (and) five.	3%

* as well, most students has some problems forming sentences e.g. with words such as sixth, sixths and sixes.

DISCUSSION

The preconception in the past that mathematics is relatively language free is a myth. In the contextually reduced realm of much of the mathematics, language can be merely an unimportant embellishment to the mathematics problem, but often single words or phrases can cause confusion or misinterpretation. This could be due to some of the typology of many Asian languages. Sometimes slight rewording can improve the interpretation of the problem for the ESL student, or allowing a student to use an ordinary translation dictionary. While English is rich in lexical alternatives, it does not become a problem for understanding unless the key words are not the main indicators of the problem.

A further problem arises when there are many new technical words to be learnt which are different in their component parts (or morphemes) from English. Mandarin generally has fewer morphemes than most other languages, in the realm of mathematics new words have been developed combining morphemes. While English uses Greek or Latin morphemes, Chinese have used current morphemes to form these new words, hence making the new word more practically understandable. However, as mathematics becomes more complex English words are often used to explain the idea or phenomena - this is more prevalent in Japanese (Fujii, 1991), e.g. the word percento. More research is being undertaken to investigate the effect of this more natural use of language to help in the understanding of mathematics.

Other research (as in McGregor and Moore 1991) has outlined some of the problems faced by the ESL student when learning mathematics in English. While many of the problems may be the same pre-tertiary students' understanding is much greater because of the greater levels of mathematical thinking they have at their disposal. Their ability to communicate is greater, but it is often unclear and stifled and not of an acceptable university standard. If ESL teachers are aware of the common mistakes students make and why they make them, they can incorporate more suitable strategies into a structured course (Galligan and Surman 1992) which will provide a suitable environment for ESL students to improve their communication skills at tertiary level.

Notes

1 Japanese, Korean and Chinese have the same regular word structure for numbers (Dunkin and Shire, p212)

2 ELICOS = English Language Intensive Course for Overseas Students

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APPENDIX A

DIAGNOSTIC TEST

	E_nM_i	E_nM_c	E_uM_i	E_uM_c	T
Ques.1					
(a) Place these numbers in order from the smallest to the biggest 3 -2 1.5 -21/4 $\sqrt{5}$ $-\sqrt{2}$	3	5	2	3	13
(b) Give three values of p which satisfy the inequality $p \geq -5$	1	7	2	2	12
(c) Round 3256 to the nearest 100	4	1	2	5	12
(d) Round -0.0652 to its leading digit	5	1	1	4	11
(e) Complete 24+☐ = -6	-	1	-	12	13
(f) Estimate 56+23x9246+125 by using appropriate rounding	12	-	-	1	13
Ques.2					
(a) Express 5/6 as a fraction equivalent with a denominator of 24	3	2	3	2	10
(b) express 1/8 as a decimal	3	1	1	7	12
(c) Find 8% of 330ml	-	-	3	9	12
(d) Simplify the ratio 24:14	1	2	2	8	13
(e) Simplify 1/4- 5/6+3/4-5/2x4/3	-	-	8	5	13
Ques.3					
(a) Evaluate $27^{5/3}$	3	-	7	1	11
(b) Simplify $(-2)^5 \times (-2)^6$	-	-	7	5	12
(c) Simplify -3(2-8)	-	-	1	12	13
(d) Evaluate $\{20-3[3+(12/4)^2]\}^3$	-	-	6	7	13
(e) Evaluate 2^0	-	-	3	10	13
Ques.4					
(a) Simplify $2x^2+5x^{-1}+2y^2+12x^2-4x^{-1}$	-	-	6	7	13
(b) Simplify $\frac{4(ab)^3b^{-1}}{2ab^4}$	-	-	3	9	12
	-	-	3	9	12
(c) Simplify $(-3x^2+4)(3-2x)$	-	-	4	8	12
(e) If $z=3x^2+2xy-y^3$, find z when x=2 and y=-1	-	-	3	10	13
Ques.5					
(a) Solve 7x+6=9x-5	-	-	5	8	13
(b)Rearrange to make x the subject of the formula: $3+y=\sqrt{5x-4}$	10	2	-	-	12
(c) If $x_1=10$, $x_2=8$, $x_3=4$, $x_4=-9$, $x_5=-3$ find $\sum x_i + \sum x_i^2$	-	-	4	2	6
Ques.6					
(a) Express 9250g as kg	3	1	1	7	12
(b) Find the sum of 0.005m and 3932mm expressed as cm.	5	1	4	2	12
(c) Convert 0.00385 into scientific notation.	6	-	1	1	8
(d) Evaluate $\sqrt{9.5 \times 10^3 + 37 \times 10^4}$	-	-	9	3	12
(e) If a=900, b=0.09 and c=90000 find (i) $a^2+b^2+c^2$; (ii) $\sqrt{a}+\sqrt{b}+\sqrt{c}$	-	-	6	5	11
Ques.7					
For each graph below state whether the graph represents a linear, quadratic or exponential relationship.	4	4	-	-	8

Ques.8					
(a)Write an equation for a straight line with slope of -4 and y-intercept of -3	3	1	4	2	10
(b)Write an equation for the straight line below	3	-	5	3	11
Ques.9 Use your calculator to find					
(a) $\log_{10}$ 1496	-	2	3	4	9
(b) e^x when x=-1.2	1	-	4	4	9
(c) ln(x+1) when x=409.8	-	-	7	4	11
(d) $e^x + e^{3x}.e^{-2x}$ when x=4	-	-	10	1	11
Ques.10					
(a) Sketch the graph of y=-x/2 + 2	2	-	4	6	12
(b) Draw the graph of y= x^2+7x+6.	-	-	9	1	10
Use the graph to predict the y value when x=-2.5	-	-	7	5	12
Ques.11					
(a) Twenty prople are given a short test. There were 20 possible marks and the results were: 18, 16, 15, 20, 13, 16, 16, 17, 16, 14, 13, 15, 16, 16, 16, 18, 20, 20, 16, 20. (i) Organise this data into a frequency distribution table	10	-	-	1	11
(ii)Construct a histogram to represent the class results.	6	1	-	-	7
(iii) Find the mode and the mean.	3	-	2	3	8

(b) The Queensland Cities Rental Vacancy Rates for April and July 1989 are given below

city	Rental Vacancy Rate (%) April 1989	July 1989
Sunshine Coast	5.36	6.43
Gold Coast	5.05	6.27
Cairns	7.79	3.83
Toowoomba	0.00	1.19
Rockhampton	0.00	1.58
Brisbane	2.90	3.40

(i) Draw a scatterplot of the data	6	-	-	-	6

(ii) Draw a line through the data points of the scattergram to show the trend in rental vacancy rates.
(iii) If another Queensland town showed a vacancy rate of 4% in April 1989, what would you predict it to be in July 1989.