

Factors Affecting the Achievement of ESOL Students in Mathematics

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INTRODUCTION

J's concerns for her ESOL calculus students centred firstly around the language barrier:

- Did they understand her explanations?
- Had she understood their questions well enough to clarify misunderstandings or confusions?
- How could she ascertain what the students already knew about each new topic?
- How could she adequately explain to them calculus vocabulary or terminology many of which have common meanings as well as specific mathematical meanings?

Secondly, J perceived the Chinese students as passive learners who relied on rote-learning, hoping to memorise and then regurgitate, who did not avail themselves of in-class opportunities to question and discuss difficulties or problems, and who were confused by detailed feedback or praise from the teacher. Were J's perceptions correct?

Research studies overseas (Allan-Rea & White, 2000; Lee, 1996; Biggs, 1996) have indicated that the notion of Chinese as rote learners may be inaccurate. Salili (1996) discusses the degree to which 'duty' and 'work-ethics' influence Chinese students' high levels of achievement. The nature of co-operative learning and collaboration in Chinese education systems may be at variance with expectations in New Zealand schools (Tang, 1996; Salili, 1996; Biggs 1996). Allan-Rea & White found that although Asian students have no problems studying mathematics in New Zealand as far as concepts and skills are concerned, their learning is complicated by 'having to understand the English language sufficiently to deal with word problems, and the meta-language used to teach mathematics' (Allan-Rae & White 2000, p.5).

This study sets out to explore the factors which affected these Chinese students' learning in calculus, - from both student and teacher perspectives. Knowledge gained from initial questionnaires, interviews, plus classroom observations and informal conversations would subsequently inform the teacher (and the school) how to develop and expand policies and classroom practices to facilitate more positive learning outcomes for ESOL students - in calculus, but with application also across the curriculum. These issues were of importance in the school which had increasing numbers of ESOL students at senior levels in several subjects.

METHODOLOGY

This small study focussed on a group of ESOL students and their calculus teacher. It used interpretivist methodology, in which the information collected was subsequently interpreted by the researcher, acknowledging that both the data collection and the subsequent interpretation would be coloured by the researcher's views and experiences.

Over a period of ten weeks, the researcher conducted an in-depth exploration of the factors influencing the achievement of a small group of ESOL students in a Year 13 calculus class, based on regular classroom observations, questionnaires, and semi-structured interviews. The ESOL group responded to an initial questionnaire, J to an informal interview, and all were later formally interviewed. Informal conversations were held between the researcher and the teacher aide, often at the end of lessons. The focus was on rich description supplemented by observation, analysis of written and taped records, and exploration of any relationship to other research literature. The data collected from observations was recorded, the questionnaire responses were summarised onto a table, and the interviews were taped and subsequently transcribed. All information was interpreted in light of other relevant research studies, and the researcher's own views and experience.

DATA COLLECTION & ANALYSIS

In an initial informal interview, J expressed her key concerns and anxieties. Information about the students' backgrounds was gathered through a written questionnaire, and more informally through discussion with both J and with the teacher-aide (who attended all the calculus lessons.) This information was collated onto a table, and key commonalities and differences identified. Regular classroom observations and written records also provided valuable background information on interactions between students, between J and class members, and between the Chinese students and the teacher-aide.

More detailed information on J's perceptions of the students' achievement and the reasons for it was obtained through a semi-structured interview which was tape-recorded, and later transcribed. The questions for this second interview were developed from comments made by J during the initial conversation, from the researcher's classroom observations, and from the students' questionnaire responses. More detailed data on the students' perceptions was similarly obtained through taped interviews, which followed-up their initial questionnaire. J supplied information on such things as test results and students' performance in assignments, which also provided comparisons between ESOL students and L1 students.

There were five periods of calculus each week, one per day. Three were in the morning, and two during the afternoon. Over a period of two months, the researcher observed three to four periods each week.

FINDINGS AND DISCUSSION

The Language Barrier

One of the most obvious areas of difficulty for the Chinese students was, as predicted, having to learn calculus in a foreign language. Their teacher was keenly aware of this problem, and continually strove to accommodate their language needs in all her teaching. Her efforts concentrated on three key areas:

- clarifying the meaning of subject-specific terminology;
- creating a classroom climate in which students felt comfortable and sufficiently at ease to seek help and clarification from the teacher;
- provision of extra resources, such as Chinese / English mathematics dictionaries, and an ESOL trained, monolingual teacher-aide in every lesson.

J realised that calculus was a subject with very advanced concepts, using advanced subject-specific terms. She commented in her interview that words with one meaning in everyday English, - for example 'hyperbolic' (meaning a rhetorical exaggeration), mean something very different in a mathematics context. The word 'expand' normally means to increase, but in mathematics often means to pull apart, and the ensuing result may be smaller rather than expanded in the conventional sense! In her teaching, J was careful to explain these kinds of words, and to highlight the mathematical meaning.

Other terms like 'additive', 'product', 'bracket', and 'series' which had an underlying common meaning, but an overlaid mathematical-specific meaning, were extremely difficult to explain - even to the English-speaking students. J described this problem as mathematics language incorporating an added layer of ambiguity. The Chinese students identified this vocabulary or terminology issue as one of the key factors which made learning calculus hard.

L: *"Sometimes we know the meaning of words, but it got a different meaning in maths or in economics or in other subjects. That not happen in Chinese. Just all the words, some special words, and strange words with all those meaning."*

F: *"I've done it [calculus] before. But some English explaining not helpful, - the words around the calculus words as well. The other meanings."*

S: *"Nothing is very bad. Only the English words is the problem."*

A typical example of the subject-specific and abstract nature of the instructional English in calculus, used by J in an explanation was -

"A unique feature of the exponential function is that it differentiates to itself."

J recognised that the jargon of the subject was an area of difficulty for all students, but felt that mathematics with calculus was a far better option for ESOL students because

it was a quite visible and far more concrete version of an abstract subject than mathematics with statistics.

*"Many kids don't cope with pulling the maths out of the language when they are English speakers, let alone doing it in their second language."
(J)*

So J put a conscious effort into explaining terms, and clarifying meanings during class. She often used humour and allegory to make her explanations more palatable and memorable.

In China, statistics and calculus were combined in the same subject, and so despite their vocabulary problems, the Chinese students reported that calculus in New Zealand was their favourite subject, and offered more opportunities for success than statistics.

A: *"Yes, I done calculus before, so calculus more easy for us. But statistics require your English more good..um, better. Statistics questions always lots of words. Have to understand the questions and then go and sort it all out. Calculus is mostly numbers. But I don't remember all the main words we need to know. It easier than other subjects. Not so much words and language."*

Wherever a term had synonyms, J used them interchangeably, and made sure that the ESOL (and other) students realised that they were all terms that shared a common meaning. For example, the terms 'exponent', 'power', and 'index' are synonyms, and so J used all three switching from one to the other, and explaining that all three meant the same thing. She also regularly encouraged the ESOL students to draw or diagram key ideas, processes, and language terms. She modelled this during class, often creating a visual representation on the whiteboard as she explained the steps in a process, or a key word. She justified this strategy saying that it would help the ESOL students particularly to handle unfamiliar language situations, like the Bursary exam, where predicting the content and the language difficulty was impossible.

J: *"A totally new language context for a question wouldn't necessarily faze Kiwi kids. But I think it would really stump the Chinese ones. And I wish to avoid that happening. I'm sure I can't avoid it, because I can't predict what's to be in the exam. But a brilliant thing about the calculus Bursary exam is that whatever they've just told you in words, they've usually diagrammed. So then, it's possible for the ESOL students to put the two together. I try to teach the kids to rely on the diagram. But then I also try to teach them to draw their own if there isn't one provided, - to go sentence by sentence.... And it's really difficult if there's a word, - for example, 'A bridge spans a distance of....' Now all the Kiwi kids say, 'OK, it goes from here to here.' But 'spans' will take ESOL kids twenty minutes! Sometimes it's fascinating, - and I've done it as an exercise a few times, - to get their exam and text papers in from the ESOL kids who've had their translation dictionaries alongside them, and to see which words they've actually written above. Often the Chinese*

characters are written above what we would consider the most inconsequential words in the sentence. It's a dead give-away that the student was unable to put together the contextual meaning of the words around it, to actually decipher the meaning. 'A bridge spans a canyon whose width is...', and the kids will get busy. 'Spans' and 'width' have Chinese characters all round them. Times like that they can't sometimes even get to a drawing."

The ESOL students themselves reported that J's drawings to accompany her verbal explanations were helpful.

L: *"Mostly I understand. She writes it on the board, and draws so we can watch. She points and explains, and it helps."*

A: *"A good teacher can draw well. Can answer any questions clearly, in many ways, many times."*

But unless the teacher-aide reminded them to copy the teacher's drawings and annotate them for later reference, there was seldom any sign that the Chinese students took this initiative for themselves.

Provision of Extra Resources

Each of the ESOL students was provided with a Chinese-English mathematics glossary / dictionary which was well-used, - though often only after prompting and reminders from the teacher and the teacher-aide.

J's request for an ESOL-trained teacher-aide in her Form 7 calculus class was greeted with some derision by her colleagues, who felt that the highest-achieving academic students in the school should not have required that sort of support.

J: *"But it's definitely working. It's definitely making a difference. Because of the importance and status of calculus, - they're [the staff] now seeing the English language component as the important factor. Plus they now see calculus acknowledged by the ESOL department, who have agreed to send a representative. Now for those [ESOL] kids, calculus is an area where I feel they could achieve extremely well, because the language barriers are not so great. They're surely bad enough here, but not so great as in some of their other subjects."*

J: *"The teacher-aide's training allows her to predict where there'll be a [language] issue. As soon as she hears me say something, she will immediately think of the linguistic connotations of what I've said. I sometimes have difficulties with that, because I'll say something, watch her, and think, 'Good grief! These [ESOL] kids won't have a clue what I mean! She's been excellent in that class, and I've tainted her with an enjoyment of maths too! Just the fact that I cared enough about their development, to get a teacher in for them has actually made a difference."*

The students knew this and they felt good."

The teacher-aide supported mainly by encouraging the Chinese students to stay on-task and to complete work in class, by reminding them to jot down diagrams and by explaining the teacher's allegorical and anecdotal illustrations. A classic example of the latter occurred when J stressed the importance of the rule / formula sheets, emphasising that formula / rule sheets were the calculus student's Bible. Although J's tone and body language clearly indicated the importance of her remark, the significance of the word 'Bible' was lost on the target audience. The teacher-aide clarified by quietly explaining to the group that to Christians the Bible was the most important book in the world, and so J was really telling them never to lose their rule sheets and to refer to them all the time. On another occasion, J reminded students to remember their 'cutlery' (use from the outside towards the inside) when using the chain rule. As the ESOL group were only familiar with chopsticks, the analogy made only confusing connections for them.

Conversational English & Use of Humour

While the teacher's use of humour certainly contributed to the positive and relaxed classroom atmosphere, the impact of her jokes was largely lost on the Chinese students, and in fact contributed to their feelings of isolation and discomfort.

A: *"I know the joking is funny, but I not understand all the words."*

S: *"It's not helpful when the teacher jokes because my English not very good and I not think it funny. I can understand the words but not why funny. Maybe words have other meaning?"*

F: *"Good teachers are experts. The students are quiet so we can listen hard. No time for joking."*

Conversational English also created problems for these students, and despite J's efforts to encourage interaction between the Chinese students and the others in the class, this seldom happened. The students gave several reasons for avoiding contact with New Zealanders - students and teachers alike.

A: *"It's hard to mix with New Zealand students, because we not understand their jokes. They don't understand Chinese jokes and fun. Different cultures understand different things."*

L: *"We don't talk to local students too much. We have different culture, different ideas about everything. Some people are not friendly, sometimes laughed at us."*

F: *"It is hard to say your feelings if you shy. Some parts I can't put in English. Sometimes I can't understand because the talk is too fast, and in the laughing."*

J's perception however, was that the Chinese girls particularly found her a somewhat humorous object, and that they quite enjoyed the interactions in class.

An overseas study (Falconer, Richmond & Wang, 2002) found that many Chinese students studying abroad felt unwilling to converse or discuss in English, could not follow humour, and had problems expressing their feelings to people with whom they felt they had little in common. Their reticence to interact was often interpreted as rudeness or boorishness, and so they were stigmatised, and socially isolated from the society they needed to become part of. Whereas it was usually expected that ESOL students would struggle with academic or 'textbook' English, the negative impact of difficulties with the affective, cultural, social side of language also had implications for the ability of ESOL students to perform on a level equal with their native-speaking counterparts.

J's concerns about the language-loading of calculus and the effects on ESOL students were justified, but even more significantly than she imagined. The abstract terminology, and the multi-meanings for common words were certainly found to be predictable barriers. But she was unaware of the extent to which her use of humour, and her efforts to promote verbal interactions in-class added to, rather than diminished the language problems for her ESOL group.

Collaboration and Student-Centred Approaches

Researchers have shown that in Confucian heritage cultures like China, there is an emphasis on collectivism, where collective welfare and social concerns are more important than individual competitiveness. Tang (1996) found that Chinese students saw collaboration as an important strategy to help them handle study situations in which mutual support was necessary. Students collaborated in literature-searches, in sharing readings, and in group discussions - including working out what the questions and assignments meant. These situations involved analysing, relating, arguing, discussing, and debating, - all requiring high level learning strategies. This collaboration and cooperative learning however, was informal, - and occurred spontaneously, outside the classroom, with students forming their own study groups, and / or seeking assistance from the teacher when and if they needed it, again outside the classroom. Within classrooms in China, the highly individualistic infrastructure with rows of desks, where tasks and assignments were oriented towards the individual allowed little opportunity for interaction. Biggs (1996) suggested that what may have appeared to Western eyes to be an authoritarian, transmission model may not have actually have been that. In his study, he described the Chinese education system as a 'more interactive, complex, social mix', in which much teacher-student interaction took place, but outside formal class time. The spontaneous cooperation he observed among students and teachers outside class was a strategy to handle an expository, competitive educational system.

In the New Zealand calculus classroom being studied here, there may well have been a mis-match between J's desire to provide time for relaxed in-class discussion and collaboration, and the Chinese students' expectation that the classroom was the place for individual silent effort.

A: *"In China, not ask any questions till the teacher finished. The students*

not talk to each other."

S: *"In China, is the teachers talking, speaking, and teaching. We not ever talk. We sit and listen. Almost all help time is after class, - have ten minutes after each class to help each other. Every period, new teacher comes to students' class. Students not change room."*

F: *"I can ask teacher to help at my study time, and after school. School days much longer and homework is very big. More subjects to do and so work takes longer. Teachers at school all the time so you can have help, but not in the class work time."*

In her initial interview, J explained that she regularly provided collaborative opportunities in class where tasks were set up following her input, so that students could use class time to discuss, question, clarify, and learn from each other, as well as from her. The reluctance of the group of Chinese students to participate in this way frustrated J, who attributed their unwillingness to apathy and / or tiredness, - or to discomfort with the New Zealand teaching style.

J: *"It's a huge issue sending a teenager out to the other side of the world to go to school, - no support,... in a country where they haven't the [language] skills to organise the power or telephone etc. My biggest worry is their not getting [educational] value for money... So families are sending their children out here to learn English and get university papers... On top of that, the struggle of being away from your family and from support and away from your home. They [the students] don't sleep! They spend hours on the internet, and hours on the Space Invaders, relaxing... The teaching style here is very different from China I think. They are taught by rote, to remember rules, and then every example given follows those rules exactly. So often they are becoming mechanics, not mathematicians."*

Passive Rote-learning, or Productive Repetition?

J's perception that the Chinese students in her class were rote-learners fits the view held by many in Western cultures, that Chinese students' educational success is due to rote-learning of formulae, to the detriment of real understanding (Allan-Rea & White, 2000; Biggs, 1996). However both these research studies found that the so-called 'rote-learning' in China could more accurately be seen as a route to understanding via repetition. These researchers found that the key difference between rote learning and repetition was student intentions: whereas meaning did not feature in rote learning, it had an important place in repetition. As the point of learning for students in China was to understand, repetition became a 'deep strategy', with close links to learning to write Chinese characters, - where young children memorised the many strokes of the Chinese characters to create intelligible symbols, requiring persistent, focused application and effort. Allied to the Confucian work-ethic was a willingness to go over and over tasks until understanding was achieved; and an intrinsic enjoyment of mastery meant that students were prepared to work harder to achieve success. This was reflected in the spontaneous collaboration set up by older students outside the

classroom to make sense of academic tasks, - as discussed earlier in this paper. This was also reflected in the long hours similarly spent studying and going over work by the ESOL students in the calculus class.

A: *"I am pleased, I am doing quite well in calculus. But I need to do more. I ask L and my sister to help me."*

L: *"Calculus is best... Economics hardest. Needs much good English to understand. The texts, articles you read need a large vocabulary to understand and then state a question and write an answer. Sometimes I know everything about the questions but I cannot speak it out, and write all the ideas. But we get a chance for us to get better English. So we must practise and practise again, and work over and over it all."*

Going over and over problems until understanding is achieved linked closely for these students to the value placed on repetition in Confucian heritage cultures (Allan-Rae & White, 2000). In those cultures, valuing achievement solely for oneself was seen as excessive, immoral egoism, and attempting tasks beyond one's ability was a virtue. In their study, Allan-Rea and White found that Chinese students ranked pleasing parents as most important, followed by career advancement, academic success, and then self-improvement. There was strong evidence also that Chinese students believed one's ability could be acquired or modified through hard work and effort. The consequences of this were sometimes tragic, when despite a student's best efforts, success was unattainable. These beliefs were similarly reflected in the New Zealand ESOL students' comments about their needing to do more work, to put in extra effort, and not being totally satisfied with their own achievement. A strong sense of loyalty and duty to their parents came through in the interviews, correlating with the researchers' findings.

F: *"I hope to do Law at university, but my parents wish me do Accounting and Business - type, ... ah.. Management. So I probably not do Law. My parents pay much money for me to come here."*

L: *"I want[ed] to go to Language School before I come here, to practise English. But my father say no. My sister not go. She work hard. She do well. I go to university here next year. Do Computers, Management. Not do calculus. I get 70 something in calculus. I think it not too good. One girl got 95%! My father say I get a good job with Computers, Management."*

Chinese parents rarely praise children, and expect hard work. Teachers in China do not use praise, and expect diligence and high levels of application and perseverance. I was often somewhat perplexed by students' confused reactions to comments like "Well done! That's tremendous!" - and to her fulsome verbal feedback on their assignments. Situations like this heightened her anxieties about her ability to interact with them effectively, and her provision of adequate support. Her strenuous efforts and the care she took to explain terminology, her modelling of processes and use of visual representation certainly met a definite need, - probably for all the students, not only the ESOL group. The four Chinese students who were the main subjects of this

study averaged 80% in the mid-year exam, compared to an average mark of 71% for the rest of the New Zealand and European students in the class. J was delighted at these results.

"Their exam results were brilliant. I'm not taking personal credit, because I deliberately doctored the exam to an extent: the maths level was exactly where it should be for Bursary mid-year. But the language level, - I really tried to cater for the people who don't speak the language to give them an equal chance to do well, - because what I'm testing here is maths, not just interpretation. It's my intention in the second half-year to do lots of Bursary-type questions with these students (two per week), so that they get used to interpreting the language presented on the page... I'll never, ever be able to meet the linguistic needs of all the kids at once. I can't do it in a class full of English speakers, and I certainly can't do it where we have the differing languages to deal with. I am aware of that, and know it can be seen as a short-coming. I can do what I can do, and then it just may be that I have to mop up afterwards. I have to do that in every class I teach. I might get to two-thirds of the class and then I'll spend the rest of the period picking up as many of the ones that have dropped off the side as I can. It's standard teaching practice."

CONCLUSIONS

The initial impetus for this study was to investigate whether J's concerns and anxieties about her ability to help her ESOL students were real or perceived, and during the course of the research, to uncover possible factors affecting their achievement. In several aspects, 'standard teaching practice' for J, - and for many New Zealand teachers, - did not fit comfortably with the ESOL students in her calculus class.

The study confirmed J's main hypothesis: that learning in a second language was a major barrier for ESOL students. Both the students' interview responses and their classroom behaviour bore this out. J took great care therefore to explain terminology, and to illustrate key concepts and processes visually, all of which went some way to alleviating the students' difficulties, and aiding their understanding of the academic language of the subject.

However, the extent to which the cultural, social, and affective aspects of English disadvantaged her ESOL group was an unexpected factor. Whereas J consciously used humour and a learner-centred teaching style in the classroom in an effort to put all students at ease, her use of both actually caused her ESOL students discomfort and some confusion. Their educational experiences in China, prepared them for a more individualistic, competitive, tightly-structured classroom environment, with collaboration only occurring spontaneously after class-time, where students sought help from each other and / or from the teacher as needed. They expected teachers here to be available for extra support after school and during the evenings as in China, where the school day is considerably extended. The students' limited conversational English caused them embarrassment when interacting with New Zealand students and teachers, and they constantly missed the point of jokes or humorous interchanges.

These difficulties may well pose more of a problem for ESOL students moving into the New Zealand secondary schooling system, than for those at university, where the delivery model is mainly a more familiar transmission mode, with collaboration occurring in small tutor groups, or informally and spontaneously outside class-time.

Perhaps the most positive factor influencing the achievement of the students in this study, was J's provision of extra resources: the Chinese-English mathematics glossaries, and more importantly, the ESOL-trained teacher aide's presence in every calculus lesson. Although the ESOL students were a little nonplussed when she first appeared, they quickly accepted the situation, and valued both the fact that J had taken the trouble to set up this extra support, and the unobtrusive assistance the teacher aide regularly provided in terms of clarification of instructions and new information, reminders about taking responsibility for making their own notes, and encouragement to complete work in-class. Any school enrolling ESOL students at any level in any subject, could well consider the value of initiating in-class support of this nature.

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