USING WORD PROBLEMS IN MALAYSIAN MATHEMATICS EDUCATION: LOOKING BENEATH THE SURFACE

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This paper reports on aspects of a project that investigated the influence of Chinese Malaysian students' schooling in a tradition of abstract, technical mathematics and rote learning on ways that they responded to mathematical word problems. Data from an action research project are reported. Supposedly "shallow" and "deep" learning are shown to be interlinked, and assumptions frequently made by Western educators about modelling and practice are questioned.

INTRODUCTION

While most Western pre-university mathematics curricula now incorporate real-life problems and applications, many South-East Asian mathematics curricula remain technical and traditional. Chi's (1999) comparison of Taiwanese and New Zealand curricula revealed that Taiwanese syllabi were comparatively archaic and did not reflect Western developments in mathematics education such as real-life problem solving. Chacko (1999), comparing American and Malaysian students, claimed that the latter learn facts through memorization, so graduates do not think deeply. Chi (1999) described the typical Confucian style of learning in the Taiwan mathematics classroom, where drills, attention to content and not the learning process, emphasis on examinations, technical questions and proofs rather than applications, and learning by memorization are all common features. Lim and Chan (1993) noted similar features in Malaysia. Reports from Japan (Kinoshita, 2000) and Hong Kong (Lucas, 2000) have indicated that students depend on rote learning in mathematics, and concerns have been expressed about the need to implement changes in teaching methods in both of these countries. In Western countries, it is generally believed that such rote learning and memorization do not enhance mathematical understanding.

Biggs and Watkins (1996) also noted that Chinese students use memorization, but concluded that there is a difference between memorizing without proper reflection and "memorization with understanding" (p. 271). Similarly, Marton, Dall'Alba, and Tse (1996) suggested that Chinese students learn repetitively in the belief that memorization could lead to understanding. Confucian tradition emphasizes understanding, reflection, and enquiry as important co-components of learning, and this is achieved by becoming "intimately familiar with the text" (Lee, 1996, p. 35).

> Learning is reciting. If we recite it then think it over, think it over then recite it, naturally it'll become meaningful to us. If we recite it but don't think over, we still won't appreciate its meaning. If we think it over but don't recite it, even though we might understand it, our understanding will be precarious. (Chu, 1990, p. 138)

Marton, Dall'Alba, and Tse (1996) pointed out that there is a paradox surrounding the Chinese learner because Chinese students have been known to perform admirably in international examinations and competitions, including at higher levels. Suh and Oorjitham (1996) reported that the countries ranked highest in mathematical achievement in a global survey were Singapore, South Korea, Japan, and Hong Kong. However, they claimed that Asian students grind good results out of memorization while their overseas peers are encouraged to be creative. They concluded that curiosity, questioning, and fun were often curtailed at the expense of producing high achievement scores, to the detriment of problem solving ability. In fact, despite the apparent successful performance of Asian students in international competitions and institutions of higher learning in Western countries, academics generally believe that Asian students are more prone to rote learning than their Western peers (Biggs, 1989, 1990). Samuelowicz (1987) surveyed 145 lecturers at one Australian university and over one-third felt that Asian students utilized only a surface approach to learning, characterized by memorization of isolated facts and fragments of arguments.

However, such conclusions need to be balanced with what is valued within countries. As much as it is admirable to produce *thinking students* or to provide *meaningful and deep learning experiences* for the students, both of which are considered desirable learning attributes by Western standards, Alatas (1972) rightly warned of uncritical imitation and unrealistic assumptions when adopting these ideas into an Eastern setting. Similarly, Bishop, Seah, and Chin (2003) cautioned that aiming for "uniformity of practices" (pp. 718–719) results from failing to appreciate the educational differences brought about by different cultural values and practices. After all, it is argued, mathematics and its practices are not culture-free (Bishop, 1988).

Deep and surface learning in the West and East

Marton, Dall'Alba and Tse (1996) identified two approaches that students adopt to learning, namely "deep" and "surface" approaches (p. 69). However, it has been found in several studies that what seem to be surface approaches can be used to develop deep understanding (e.g., Marton & Wenestam, 1987; Marton, Carlsson & Halasz, 1992). Kember and Gow (1990) postulated an "understand-memorize-understand-memorize" sequence (Biggs & Watkins, 1996, p. 271; Hess & Azuma, 1991) where memorizing leads to improved understanding.) It appears that different aspects and perspectives are focused on with each repetition, deepening and widening understanding. Marton, Dall'Alba and Tse (1996) summarized this paradox:

> In the process of repeating and memorizing in this way, the meaning of a text is grasped more fully: "In the process of repetition, it is not a simple repetition. Because each time I repeat, I would have some new idea of understanding, that is to say I can understand better." It is upon this use of memorization to deepen understanding that the solution of the paradox of Chinese learner rests. (p. 81)

Hence, Western educators may equate Chinese learners' memorization to rote learning in error, suggesting that it is necessary to exercise caution when making

assumptions about methods from other cultures (Marton, Dall'Alba & Tse, 1996). Biggs and Watkins (1996) explained this phenomenon further:

> … the difference between those who use a lot of repetition in learning for understanding, and those who learn for understanding without much repetition, derives from perceived task demand, which differs between cultures … what differs are the perceived demands of common tasks learners from each culture typically face in the home environment. Chinese learners come to use repetition strategically more often than Westerners do in their attempts to understand their world. (p. 272)

In Malaysia, Chinese schools produce impressive results in mathematics. Their school mathematics is thought to be "superior" to National school mathematics because society perceives mathematics to be only computation and operations. Chinese school students pride themselves on being able to recite their multiplication tables by Year One, and parents spend thousands of *ringgit* to send children to mental arithmetic classes. Fast arithmetic computations by using either the abacus or a finger technique are learnt by rote, and young Chinese children who help their families run small businesses excel in computation. However, it is fair to question whether achieving speedy mastery or arithmetic ensures good mathematical understanding at higher levels—but the college students referred to in this research report attended both primary and secondary schools where such questions were never asked.

In this paper, we report on one aspect of a two-and-a-half year action research project where the main aim was to investigate whether Chinese Malaysian post-secondary students who study mathematics as an enabling science are able to learn mathematics more meaningfully when it is taught not by memorization of procedures but by using word problems. Instead of the usual fare of drills and abstract technical questions, word problems were featured extensively in the curriculum. The specific research question that we focus on in this report is whether the students who apparently prefer "surface learning" in mathematics were able to appreciate deeper concepts and contexts in mathematical word problems. Across a number of action research cycles, the students were encouraged to engage in discussion, peer-group activities and reflection—all of which are Western approaches designed to bring about "deep" learning and not usually adopted in traditional Malaysian education environments.

The introduction of Western teaching methods is increasing in South-East Asian countries, so it is important to learn more about (a) the effects of use of problems and Western classroom methods, and (b) how these new approaches might be adapted to improve teaching processes and hence learning outcomes.

METHOD

This research was undertaken in a Malaysian private college, with a total of 290 students enrolled in the first semester of a computing and information technology diploma course. The majority of the students were 17-18 year-old secondary school leavers from a Chinese school background. Seven 14-week cycles of action research were carried out over two and a half years, using seven cohorts of students.

Action research was appropriate because the overall aim was to explore the possibilities and challenges of instituting change in teaching, over time. Data on students' achievements, interest levels, beliefs and attitudes, and mathematical performance were collected. Instruments used included questionnaires, interview schedules, journal notes of conversations and observations, as well as each cohort's mathematics work and exams. Daily entries were made in a reflective journal. Data from these sources were sorted under headings including the use of word problems, collaborative and reflective learning, learning mathematics in a second language, and the incorporation of values into mathematical concepts and practices (see Chan Kah Yein, 2004). Analysis of data included triangulation by colleagues and a student.

One of the authors, Chan Kah Yein, was the teacher-researcher. Each action research cycle involved making a change in relation to the use of word problems, including using students' interests, consideration of professional needs of the students, small-group discussions, encouraging peer-group reflection, exploration of inculcating values in mathematical concepts and practices, and tackling issues about learning mathematics in a second language. Each new initiative grew from on-going data-analysis and reflection (Kemmis & McTaggart, 1988). Deep and surface learning were investigates in Cycles 4 through 7 as this issue emerged and was problematised towards the later part of the project. In this paper, we report some aspects of what happened in relation to this particular issue.

RESULTS AND DISCUSSION

Since the students had been raised in an environment that privileged mastering procedural skills and ready-made models for solving problems, it was initially assumed by the teacher that the students were using a surface approach to learning, with rote-based and low-level cognitive strategies, as opposed to a deep approach that is characterized by deriving meanings from the learning material. This proved true as they tried tackling unfamiliar word problems for the first time. The following is an example of a word problem used in Cycle 4:

$$\text{Compound Interest Formula} \qquad A = A_o \left(1 + \frac{r}{k} \right)^{kt}$$

where A = amount after t years, A_o = initial deposit, r = interest rate per annum (in decimals), k = number of times interest is paid in a year, t = number of years invested

Find the amount of money that should be deposited in an account paying 8% interest per year, compounded quarterly to produce a final balance of RM100,000 in 10 years.

First, most students thought they had to find the value of A instead of A_o because that was more predictable and straightforward. They did not bother about the phrase "final balance" in the question, but assumed that the RM100,000 would be the value of A_o. Second, the phrase "compounded quarterly" also did not mean much to them:

CKY: The value of k is how many times the bank pays you interest in a year. For example, if it is annual compounding, the bank pays you interest only

once a year, so the value of k would be 1. If it is semi-annual? (Silence) Semi … what does "semi" mean? As in semi-finals in a football match…?

Kah Sui: Half! So k is half!

CKY: You're right that semi means half, but the phrase is semi-annual, so it means interest is paid every half year, every six months. So how many times do you get interest in one year?

Daniel: Half.

CKY: Not quite. They give you interest every six months, every half year, so …

Kah Sui: Oh … two! k is two.

CKY: Yes, very good. Now, what about "quarterly"?

Kah Sui: Three!

CKY: Not quite … quarterly means you divide the year into quarters, so, it IS three months. You get interest every three months, but how many times would you get interest in a year if they give it to you every three months?

Kah Sui: So, k is four? (wrote it down in his notebook)   *Cycle 4, Interview notes*

The students were most interested in copying and memorizing the values of k:

Annually : k = 1 ; Semi-annually : k = 2 ; Quarterly : k = 4 ; Monthly : k = 12 ; etc.

It appeared that memorizing the corresponding values of k was more important than understanding what periodic compounding meant or how the values of k could be derived from understanding periods of time. It was thus conjectured that the students were typical surface learners and that exposing them to word problems would prove a good way to engage them in deep learning. Over time, they did learn the common principles underlying such facts, and hence to focus more on general meanings.

In Cycle 5, a different picture emerged:

CKY: I notice you prefer technical questions to word problems …

Eng Li: I like the technical questions, Teacher. They are challenging. I wish you'd us give more difficult ones to do.

Zhi Wei: … we prefer the technical question. It makes us think more, especially the difficult ones.   *Cycle 5, Interview notes*

Such remarks changed the teacher's earlier judgmental stance, and raised questions about whether it was fair to assume that the students were surface learners just because they preferred abstract technical questions. Was it right to assume that word problems require a deep approach to learning whereas technical questions do not? While word problems may provide more opportunities for discussion and reflection, and for relating mathematics to other aspects of life, perhaps technical questions could provide an equivalent level of challenge, meaningful learning, and satisfaction.

Eng Li: Maths is logical. … I just need to practise and use my brain. And it is challenging … It helps me build my mental foundation … makes me think

> logically … I think this is very useful for me when I write my computer programs … This training would be useful for me.

Eng Li's comment showed that he viewed mathematics as a tool whose knowledge can be transferred to other subjects. He valued this application aspect of mathematics and how mathematics helped build his mental abilities to think logically. To him, this aspect of abstract mathematics was meaningful in its own sense. Other students also expressed appreciation of working with just numbers and symbols:

> Eugene: I like the problems with lots of numbers … numbers don't lie … Maths is straightforward and accurate. No twisting and turning around … it's like there's just one thing, and no matter how you look at it, from whichever angle … it comes back to that one thing. But with other subjects, it's like you can see it from so many different angles and they're all different!

Eugene's comments demonstrated that he had internalized the universality value inherent in mathematics. To be able to view mathematics in this way was also a form of problematizing and sense making, and hence constitutes one form of reflective learning. Hiebert et al. (1996) suggested that reflective inquiry and problematizing depend more on the students and the culture of the classroom than on the task itself. They explained:

> … tasks such as 63 minus 37 can trigger reflective inquiry because of the shared expectations of the teacher and the students although they may look routine … Whether they become problematic depends on how teachers and students treat them. (p. 16)

Given that the students who practised the drills diligently were the ones who eventually performed well in the range of questions examined, repetition may have helped to develop their mathematical understanding. It would also seem that Kember and Gow's (1990) *understand-memorize-understand-memorize* sequence—a routine that was clearly observable in the classroom—could have lead to improved understanding and performance. The students' beliefs were not identical:

> Suet Yen: The models you gave us (for the word problems) were very useful. It's like you just remember those few models, and then, you identify the question and apply the model, and there's your solution. Actually, there are only a few models. You just have to understand which model fits which type of question.

> Yew Loon: Hey, but I don't like to memorize the models, I prefer to approach each question independently and find a method for it. It's better that way. After all, it's mathematical thinking that is required, isn't it? We don't need models, though they are useful. If you have to depend on models, then what happens if you encounter a brand new type of problem which does not fit into any model?

Here, Yew Loon was ready to move on to the level of divergent thinking and explore new ways of solving problems on his own whereas Suet Yen had just gained enough confidence after practising and applying the models given.

CONCLUSION

In this paper we have focused only on those aspects of the research project entitled "Fostering meaningful learning by using word problems in post-secondary mathematics" that pertain to deep and surface learning in the use of word problems with non-English speaking students in a college programme.

We conclude at this point that most of the students in this project felt a need to practise sufficient examples before they developed adequate confidence and curiosity for more independent and diverse ways of solving problems. Hence, it seemed that what could be termed *surface approaches* can be used to build a foundation for the use of deeper learning approaches. Also, it seemed that technical problems were not inferior to word problems in terms of their ability to lead to deeper learning. What appeared to matter was how the students approached the problems, and how their mathematical thinking developed as a result of having tackled numbers of problems.

Last but not least, the research seemed to provide some justification for Alatas' (1972) caution about uncritical imitation, or more accurately in this case, making uncritical *assumptions* about students' ways of learning and perceiving mathematics. Instead, we need to look beneath the surface and recognize the fact that mathematics is not culture-free, and a deeper understanding of how repetitive practice and deeper learning intertwine is important.

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