INVESTIGATION OF THE TEACHING AND LEARNING OF RATIO AND PROPORTION IN MALAYSIAN SECONDARY SCHOOLS

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The present study seeks to explore the complex relationship between teaching and learning that takes place in Malaysian mathematical classroom settings. Specifically, the study investigates the relationship between teachers' pedagogical content knowledge, instructional classroom practice and students' learning with a particular focus on the teaching and learning of ratio and proportion. The research is still on going and this paper briefly. outlines some of the findings. The preliminary results indicate that in Malaysian classroom settings, students' approaches to solving ratio problems varied considerably from formal to informal strategies. This finding highlights the need for wariness when interpreting the relationship between teaching and learning as teachers and students are complex human beings in a classroom setting that carries many different aspects.

Introduction and Background

The issue of students' learning has been of considerable concern for a very long time in Malaysian secondary schools. Until recently, many efforts towards improving students' mathematical learning have been made by the education department. As an educator throughout the 1980s and early 1990s, I believed that in the process of teaching and learning, a living classroom is inhabited by complex human beings, teachers and students. It was apparent to me that in this classroom situation, focusing on learning implied looking at the breadth and richness of connections which students can make with mathematical ideas, resulting either from their personal interpretation of knowledge or constructed from their experience of carrying out mathematical activities. These mathematical ideas may be experienced and constructed from the activities which the teacher presents to the students, which tend to focus on drill and practice and rote learning in the Malaysian context. This reflects to me the issue that a teacher as the primary mediator between the subject and the learner in a classroom is believed to playa major part in creating the environment in which students can best learn mathematics (Lerman, 1993). As a mathematics teacher of several classes, I realised that my affective and cognitive attitudes towards teaching differed with differential outcome of students' learning. I realised as well that traditionally the

conventional teaching of mathematics has been viewed as 'chalk and talk'. In Malaysia, the education system is highly centralised and appears to be highly co-ordinated and controlled. It is possible to say that such control leaves little room for local innovations. In practice, however, deconcentration or devolution of power as an attempt towards more decentralisation is gradually setting in due to several explicit and implicit factors that seem to have influenced classroom practice.

In reflecting on these issues I began to consider how and what part the teacher plays in achieving the goal of students' learning mathematics. In other words, the issue of how the teacher influences students' learning is of particular concern. Nevertheless, there are many issues to be investigated. I thus embarked on research work which aimed to explore issues related to teacher and student, and to focus on the complex relationship that exists between teaching and learning. There have been extensive investigations into teaching perspectives that tended to focus on the teacher's influence on students (McLeod, 1994; Pehkonen, 1994). It seemed that examining teachers' knowledge would provide an opportunity to gain insight into the teaching process and its influences on teachers' practice and students' learning. However, in spite of the continuing effort to provide more information about how teachers' knowledge influences their teaching practice and students' learning (Brown & McIntyre, 1993; Cooper & McIntyre, 1994), this area has not received sufficient attention within the Malaysian teaching setting. In this regard, therefore, more specific goals for the present study are to work towards a better understanding of teaching behaviours adopted by Malaysian teachers that account for learners' differential degrees of learning, with a particular focus on ratio and proportion.

The topic of ratio was selected as the subject of application in the above investigation due to the demand for the application and understanding of this concept across the school curriculum. Furthermore, as Griffin (1988) commented many mathematical topics are essentially contexts for dealing with ratio and yet students have great difficulty handling this notion. In this regard, the volume and breadth of work undertaken by Piaget has been the starting point and stimulated the work in the development of proportional reasoning. The relation of Piagetian theory to the proposed study provides a jumping-off point for replication and adaptation to other studies of similar concern. Replications and adaptations of some of the Piagetian tasks have been used by a number of researchers for the last 35

years, with initial research undertaken by Piaget and Inhelder (1958) on a balance beam tasks. The work carried out by other researchers was reviewed in the present study, one of which is Hart (1978, 1981, 1984). Hart has been involved in an investigation which is designed to assess the understanding of ratio problems by secondary pupils. Specifically, the main features of her work, have been to identify strategies (see Table 1) and methods used by secondary school students when engaged in solving ratio problems. A similar study on ratio and proportion was, however, carried out in 1988, from a different perspective (palanisamy, 1988). Taking the context of ratio and proportion it is the aim of the present study to investigate the complex relationship between teaching and learning.

Table 1: Characterisation of Pupil Strategies

Pupil Strategy	Characterisation
Scalar	The relationship between two quantities in the same unit is evaluated multiplicatively and the same relationship is established in the amounts in the other unit.
Functional	The relationship between two quantities in different units is evaluated multiplicatively and the same relationship is established in another corresponding quantity that comes from the two units.
Rule-of-three	The rule of a/b = c/d is used with three known values and the fourth to be found
Doubling or Halving	The required amount is obtained by doubling or halving the amount given.
Unitary	An amount per unit is established and it is extended to the required amount by multiplication.
Building-up	A relationship is established within a ratio and extended to the second ratio by addition.
Addition	The difference between the amount is assessed and applied to determine the required amount by addition or subtraction.
No strategy (No working/right answer, No working/wrong answer, No answer)	No procedure or working is shown that would lead to any identifiable strategy.

Method

Subjects: The sample of the study consisted of a group of 160 students aged 14-15 and a group of 5 teachers all involved in teaching these students. They were selected at random from two schools in Malaysia, which represent typical Malaysian government schools.

Methodology: Within the study, three types of data were collected: systematic classroom observations, semi-structured interview with teachers and diagnostic tests on ratio for the students. The diagnostic test was adopted from Hart's Chelsea Diagnostic Mathematics Test in Ratio (1985). It was used as the diagnostic test for the students since there is a similarity in the test questions to that of the ratio syllabus used in Malaysia. The test which

consisted of 8[1] items was administered to the sample students at the end of the ratio teaching sessions. For systematic classroom observation, all the teachers were observed whilst teaching ratio and a total of 5 teaching sessions were video taped. The ratio teaching sessions were audio-recorded as well. The semi-structured interviews were carried out with all the teachers who completed the ratio teaching sessions. For data analysis, I will use a combination of both quantitative and qualitative approaches.

In this paper I will discuss some of the findings from the students' performance in the ratio diagnostic test. The results and the discussion that follows will focus only on one group of students' responses to the Mr. Short and Mr. Tall item *(Q: Mr. Short has a friend. Mr. Tall. When we measure their heights with matchsticks. Mr. Short's height is four matchsticks. and Mr. Tall's height is six matchsticks. How many paperclips are needed for Mr. Tall's height if Mr. Short's height is six paperclips?)* For analytical purposes, the students' approaches to solving this item are characterised according to the strategies listed in Table 2.

Students' Performance **In** Ratio

Results: This section presents the strategies of the students in relation to the task described above. The results are presented in Table 2 below:

Table 2: Approaches as Exhibited by the Malaysian Pupils to Mr. Short and Mr. Tall diagnostic test item.

Item Mr. Short and	Scalar	Functional	Rule-of-three	Doubling	Unitary	Build-up	Addition	No work/ right ans	No ans	No work/ wrong ans	Total no. Of student
Mr. Tall	0 (0%)	3 (7%)	3 (7%)	0 (0%)	10 (24%)	1 (2%)	8 (20%)	3 (7%)	3 (7%)	10 (24%)	41

Discussion of results: The results presented are for one group of students (N = 41) which was chosen as the sub-sample to focus specifically on their performance in ratio. Table 2 shows the approaches as exhibited by the students when solving this problem. 10 out of 41 of the students exhibited the unitary method with different computational procedures, such as the traditional unitary computation that involves writing mathematical statements one beneath the other. Only one student dealt with the build-up method comfortably within the context that made sense to her. She seemed to utilise the information of '4 matches for 6 paperclips' relationship, then used this relationship as a countable unit to find the answer as a build-up method. 3 of the students from this group employed the functional approach

1: 8 items: recipe, eel, Mr. Short & Mr. Tall, 'K', bill, percentage, metal, 'similar'.

and 3 employed the 'rule-of-three' ratio method. In the functional approach, it appears that to reach the answer, the students used a similar variation of procedures to that of the build-up method. The students used the ratio of 6 paperclips to 4 matches as a countable unit to find the solution. None of the students used the scalar or the doubling method. 8 out of 41 students used the incorrect 'additive strategy'. 16 students from this group seem to engage with difficulty in looking for the answer which will lead them to solve the problem without any known strategy, such as no answer, no working with right answer and no work with wrong answer. The results seem to indicate that some students employ the well structured formal methods taught by the teachers, such as the unitary, functional and the rule-of-three methods, which is different from Hart's findings. None of the students used the doubling method whilst in Hart's work, this method was one of the approaches used to solve this problem. However, others seem to create their own methods that made sense to them, such as the additive strategy and the building-up strategy. The use of the additive strategy by 8 out of 41 students shows a similarity to that of Hart, where there is a constant effort to obtain the answer by using addition in some form or other.

The findings indicate that besides having the idea of the informal method of solving the problem as the explicit tool to start a solving process, such as the additive and the build-up approach, students also seem to make use of the formal taught methods, such as unitary, functional and rule-of-three which makes use of a 'multiplicative strategy'. The preference for a method that makes use of a 'multiplicative strategy' seems to reflect the algorithmic methods which are taught by teachers in Malaysian classrooms. The students, however, do not only develop the methods that rely on the taught algorithm, they also seem to integrate mathematical knowledge gained from the teacher with their own particular knowledge, creating the informal methods that make sense to them. For the present study, it may be too early to offer such a distinct finding. However, the fact that students' approaches to solving ratio problems varied from formal to informal methods does suggest an influence.

Some Concluding Remarks

In the next phase of the study the data analysis of students' performances in ratio problem solving will continue and will be used as part of the structural framework in investigating the phenomenon of what and how teachers integrate their knowledge of mathematics into instructional practices that influences students' learning. With the intention of probing the

roots of the teachers' pedagogical content knowledge, it is the aim of the present study to explore issues such as: Do teachers' views of the nature of mathematics and of the teaching/learning of mathematics influence their practices?, What and how does the teacher's pedagogical content knowledge influence the students' learning? Towards the end of a long journey, I will look more carefully at the analysis of the quantitative and qualitative data collected through systematic classroom observation and the semistructured interview of the teachers respectively, which will then lead us to offer the interesting findings of the complex relationship between teaching and learning that focuses on ratio and proportion in Malaysian secondary schools.

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