STUDYING THE DISTRIBUTION OF RESPONSIBILITY FOR THE GENERATION OF KNOWLEDGE IN MATHEMATICS CLASSROOMS IN HONG KONG, MELBOURNE, SAN DIEGO AND SHANGHAI

David Clarke

University of Melbourne

Seah Lay Hoon

National Institute of Education (Singapore)

In this project, the clichéd 'student-centred' versus 'teacher-centred' dichotomy has been reconceptualized in terms of the distribution of responsibility for knowledge generation in the classroom and applied in the analysis of 'well-taught' mathematics classrooms in Melbourne, Hong Kong, San Diego and Shanghai. This analytical approach enabled the practices of competent teachers in two 'Asian' and two 'Western' settings to be compared in a more meaningful and insightful fashion than previously possible. This analysis was able to distinguish one classroom from another on the basis of the process whereby mathematical ideas are introduced into classroom discussion and subsequently revoiced and accorded authority. In particular, the methodology and analytical technique employed provided the opportunity to track the movement of mathematical ideas in either direction across the public/personal interface. Critical similarities and differences were identified between and within the classroom practices documented in each country with respect to the distribution of responsibility for knowledge generation.

INTRODUCTION: A THEORY OF CLASSROOM PRACTICE

The theory of learning on which this paper is grounded is one that starts from the social situation of the individual in interaction with others, but which accords a significant role to the individual's interpretive activity. Particular significance is attached to social interaction, and learning proceeds by the iterative refinement of intersubjective understandings that include social and content-specific (in this instance, mathematical) meanings, as well as values and modes of collaborative practice. These understandings are enacted as progressively increased participation in valued practice, including the appropriate utilisation of technical language. Essential to an understanding of the nature of social activity in classrooms is the co-constructed nature of the practices of these classrooms, and the role of negotiation not as a subordinate activity *through* which classroom practice is constructed but as an essential activity *of* which classroom practice is constituted (Clarke, 2001).

Teaching and Learning are not simply distinct but interdependent activities that share a common setting, rather they should be conceived as aspects of a common body of situated practice and studied as such. It is ironic that recognition of this fundamental unity is enshrined in several languages other than English and that the

dichotomisation of Teaching and Learning may be, in part, an artefact of our use of English as the lingua franca of the international Education community (this argument is outlined in greater detail elsewhere (Clarke, 2001)). Classroom Practice as a form of communal collaborative and negotiative activity is constituted as it is constructed through the participation of both teachers and learners and only understood (and consequently optimised) through research that accords value and voice to all participants. It is for this reason that the Learner's Perspective Study, of which this paper is a product, supplements the multi-camera documentation of classroom activity with post-lesson reconstructive interviews of the participants.

THE DISTRIBUTION OF RESPONSIBILITY FOR THE GENERATION OF KNOWLEDGE

Popular in recent educational literature as descriptors of classroom practice are the terms 'teacher-centred' and 'student-centred.' These terms vary in definition and in use, but they represent a key dichotomy driving much of contemporary Western educational (particularly pedagogical) reform. From one perspective they appear to offer mutually exclusive alternatives with regard to the location of agency in the classroom. Western educational reform advocates student-centred classrooms, and research in Western settings confirms the value of practices associated with these classrooms (Chazan & Ball, 1997; Clarke, 2001). Asian classrooms have been typified as teacher-centred by both Western and Asian researchers, yet the students in these classrooms are highly successful in international studies of student achievement ('The Asian Learner Paradox') (Leung, 2001). Recent research in Chinese classrooms suggests that classroom practice is misrepresented by such a dichotomy (Huang, 2002) and that a theoretical framework is needed by which the 'teacher-centred' and 'student-centred' characteristics of classrooms can be more usefully characterised and investigated, without the assumption of an absolute dichotomy.

Clarke and Lobato (2002) (and subsequently Lobato, Clarke & Ellis (in press)) have proposed a theoretical reformulation of teachers' communicative acts in terms of function rather than form. This reformulation is founded on the distinction between "eliciting" and "initiating." By focusing on function (intention, action, and interpretation) rather than form, some of the difficulties experienced in analysing the efficacy of teacher practices from a constructivist perspective are overcome. Such a framework offers a more incisive tool for the analysis of the teacher's contribution to classroom discourse. In particular, it offers a language in which to frame either the devolution of the responsibility for knowledge generation from the teacher to the student, or, alternatively, the concentration of that responsibility in the teacher. For example, teacher acts that take the form of a question but have the function of telling can be identified and the responsibility for the initiation of a new mathematical idea can be correctly located with the teacher rather than the responding student. Equally, the capacity of the student to contribute to the generation of knowledge can be recognized, and classrooms can be compared according to the extent to which the

student is accorded the opportunity to make this contribution. The fundamental consideration is the distribution of responsibility for knowledge generation.

There is general assumption in most literature that classroom discourse encompasses any form of interactions that take place in a classroom. Nevertheless, research has seldom studied all the different forms of classroom interactions. Research involving classroom interactions has tended to focus on either the teacher's talk (eg., Wilson, 1999; Young and Nguyen, 2002) or teacher-students' interactions in either whole class (e.g., Klaassen and Lijinse, 1996, and Seah, 2004) or group discussion (e.g., Knuth and Peressini, 2001). There have been however very few studies, if any, that took into account the role of student-student interpersonal interactions in generating knowledge in the classroom. In our study, a more integrated and comprehensive approach was attempted by analysing both public interactions in the form of whole class discussion and interpersonal interactions that took place between teacher and student and between student and student. Interpersonal student-student interactions available for analysis were restricted to a focus group of up to four students. While this approach did not allow all interactions that took place in the classroom to be studied, it provided us with an avenue to track the generation of knowledge that could occur in both the public and interpersonal domains. In this paper, we report the use of an analytical technique applied to data from mathematics classrooms in four distinct cultural settings to explore the nature of the distribution of the responsibility for knowledge generation.

RESEARCH DESIGN

Data collection was undertaken consistent with the 'complementary accounts' approach discussed in detail elsewhere (Clarke, 2001). In the Learner's Perspective Study (LPS), three video cameras documented teacher and learner actions for sequences of at least ten consecutive lessons and this video record was supplemented by post-lesson reconstructive video-stimulated interviews with teacher and students, together with test and questionnaire data and copies of written material produced in class and interview. This data collection procedure was carried out in three mathematics classrooms in each of the participating countries. In each case, the teacher was identified as competent according to local criteria. In each country, the three mathematics classrooms were selected to provide diversity of socioeconomic context within a single major urban setting – Hong Kong, Melbourne, San Diego and Shanghai for the data analysed in this paper.

All teacher classroom utterances and all statements by focus students, together with post-lesson interviews with teacher and students were transcribed and translated into English. The classroom transcript of each lesson was scanned for terms or phrases that expressed, represented, illustrated or explained mathematical concepts or understandings. In this paper, these terms or phrases are referred to as "math-related terms". These might take the form of conventional mathematical terms such as

'gradient' or everyday expressions such as 'slope' or 'steepness'. These math-related terms were classified into three categories:

1. Those 'primary terms' that corresponded to the teacher's stated instructional goal (in lesson plan or interview),

2. Those 'secondary terms' that were subordinate to or supportive of the teacher's main instructional goal (frequently terms that had been introduced in previous lessons or which referred to familiar everyday contexts and which served to explicate the meaning of those terms central to the lesson's intended focus),

3. Those that appeared infrequently and fleetingly in the course of classroom discussion (in either public or interpersonal statements). These were referred to as 'transient terms.'

Once all math-related terms had been identified in the classroom transcript of a particular lesson, the next step involved identifying the speakers from whom each term originated and those by whom the term was then subsequently revoiced (or not). The time at which each math-related term appeared in the transcript was also noted. Each math-related term was annotated on the basis of whether it was mentioned in the personal or public domain. For the purpose of coding, interactions meant for the public domain were defined as those for which the intended audience was the whole class regardless of the number of individuals actually attending to the statement. Similarly, terms were coded as 'personal' if their intended audience were a single individual or a small group, even where the statement may have been audible to the whole class. The purpose of this distinction was to identify the social context in which each math-related term was first introduced and subsequently revoiced. In this way, it was possible to examine the assimilation of terms introduced in the public domain into student interpersonal discourse and, equally, the introduction of terms originating in student interpersonal conversations into the public arena.

The occurrence of each term was then displayed in a tabular form analogous to Barnes' "flow of ideas" display (Barnes, 2004) or to the resource utilization planning charts of engineers (from which both tabular representations derived). If these math-related terms are thought of as resources drawn upon during the collaborative process of classroom knowledge construction, then the analogy is not inappropriate. Table 1 has been significantly abridged for reasons of space: Only the first 6 minutes of the lesson are displayed and only a subset of the lesson's math-related terms are included. The terms are separated within the table by bold lines into the three categories and a brief description is provided of the classroom activity coincident with the occurrence of the various terms. Each vertical column corresponds to one minute and the occurrence of each term is designated by speaker (T = teacher; Andrea, etc = student), by time-code (eg 06:13, seconds and frames within the designated minute) and by "P" if the utterance was an 'interpersonal' rather than a 'public' utterance.

Mathematical Idea/Term	0 – 1 mins	1 - 2 mins	2 - 3 mins	3 - 4 mins	4 - 5 mins	5 - 6 mins
Current Activity	(0:00 to 2:57) T reviewed the things learnt in the previous lesson with the class; drawing *x*- & *y*-axes (coordinate axes), locating the coords. of a pt & features of 2 points having the same abscissa.			(2:57 to 8:19) T discussed the method to find the coords. of a point and marked the 5 points on the blackboard: (1)find the quadrant where the point belongs; (2)draw a line perpendicular to *x*-axis & a line perpendicular to *y*-axis; (3)locate & note coords. of point.		
Coordinate(s)	T (17:15)	T (06:26) Eve (07:15) T (09:15) T (50:01)	T (07:13) T (03:19)			T (27:19)
Area						
Abscissa		Anthea (30:14) T (32:05)		T (03:19) T (34:11)		T (27:19)
x-axis	Sam (43:17) Eve (52:26) T (56:03)	T (32:05)		T (34:11)	T (08:15)	Anthea (29:15)P
Ordinate		Simon (48:17) T (50:01)		T (24:13)	T (08:15)	T (27:19)
y-axis	Sam (43:17) T (52:09) Eve (52:26)	T (09:15)			T (49:29)	Eve (30:12)P
Transient Terms	Eve (51:04): Coordinate axis.	T (50:01): … rectangular coordinate plane.	Anthea (18:22)P: rectangular plane			Eve (30:12)P location

Table 1. The Distribution of Responsibility for Knowledge Generation

The findings that follow are the result of the application of this analytical approach in a preliminary analysis of such tabular representations of the transcribed classroom discourse from between nine and fifteen lessons in each of the four cities. Interpretation of the status and origin of the math-related terms was supported by the teacher and student interview data.

RESULTS: AN OVERVIEW

Our intention in this paper is to illustrate both the viability of the distribution of responsibility for knowledge generation as a conceptual frame through which to compare classroom practice and the utility of an analytical procedure by which it might be applied. Given the constraints of space, we can only summarise some

general trends revealed by our analysis in terms of distinguishing characteristics of the classrooms studied.

Shanghai (Lessons SH2 L04-05 and SH3 L01-05)

The style of teaching in both Shanghai schools analysed was such that the teachers generally provided the scaffolding needed for students to reach the solution to the mathematical problems without "telling" them everything. Hence, one could find quite a few math-related terms that were introduced by the students during public discussion which the teacher had not taught. A particularly powerful example of this devolution of responsibility occurred when the teacher in SH2-L04 (Shanghai School 2, Lesson 4) drew the class's attention to an alternative method of solving simultaneous equations being used by a student which the teacher described as more 'elegant' than the standard (textbook) method.

Hong Kong (Lessons HK1 L09-11, HK2 L05-07 and HK3 L05-07)

Students in the Hong Kong classes studied were generally not given the same opportunities to contribute during lessons in comparison with classes in the other three cities studied. The teachers generally stated very explicitly every step for solving the mathematical problems discussed. In other words, students were guided through the steps for each problem type with very little opportunity for original thought or input into class discussion. Where a new math-related term was introduced into whole class public discussion, this was either done by the teacher or by a student in response to very explicit prompting from the teacher. There were, however, math-related terms that occurred for the first time in interpersonal conversation between students, but were not subsequently voiced in the public arena.

Melbourne (Lessons A1 L04-06, A3 L06-08 and A4 L05-08)

In two of the Melbourne classrooms (A1 and A3), math-related terms were frequently first introduced into whole class discussion by the students but this was most commonly in response to specific teacher questions and consisted mainly of terms taught in previous lessons. The teacher's practice of regularly checking student knowledge of previous content provided frequent instances of student introduction of relevant math-related terms. Classroom activities offered frequent structured opportunities for students to contribute math-related terms whose emergence was anticipated and guided by the teacher.

Melbourne classroom A4 provided several examples of math-related terms introduced for the first time in interpersonal conversation between students. Examples of such terms are: obtuse, millimeters, degree, co-interior, and complementary angles. The richness of the student-initiated math-related terms in interpersonal interactions between students reflects the comparatively lower level of overt guidance provided by that teacher.

San Diego (Lessons US1 L03-05, US2 L01-03, US3 L01, L02, & L05)

In classes US1 and US2, student introduction of math-related terms was most frequently elicited by direct teacher questioning. Such terms occurred either as the names of concepts previously taught, in descriptions of patterns identified or in explanations of mathematical procedures employed, typically expressed in terms of specific mathematical rules. In contrast, in US3, the majority of math-related terms introduced by students arose as part of student descriptions of their problem solving attempts. These were typically elementary mathematical terms such as 'equation,' 'squared,' and 'triangle.'

DISCUSSION

As examples of 'Asian' classroom practice, the Hong Kong and Shanghai lessons analysed displayed greater differences in the distribution of responsibility for knowledge generation than those evident from comparison of 'Asian' and 'Western' lessons. Within the sets of lessons analysed for each city, significant variation was evident. The practices of SH2 provided some powerful supporting evidence for the contention by Huang (2002) and Mok and Ko (2000) that the characterization of Confucian-heritage mathematics classrooms as 'teacher-centred' conceals important pedagogical characteristics related to the agency accorded to students; albeit an agency orchestrated and mediated by the teacher. Our preliminary analyses have demonstrated the utility of 'the distribution of responsibility of knowledge generation' as an explanatory framework capable of distinguishing usefully between classroom practices in both 'Asian' and 'Western' settings.

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