INVESTIGATING MATHEMATICAL INTERACTION IN A MULTILINGUAL PRIMARY SCHOOL: FINDING A WAY OF WORKING

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How is it possible to investigate student interaction in a multilingual mathematics classroom? As researcher, I have little access to students' language, culture or experience, making it difficult to make claims about their meanings or interpretations as they work together on mathematics tasks. This paper discusses the development of a methodology based on the discursive psychology of Edwards (1997), which makes possible an investigation of the participation of English Additional Language (EAL) learners in mathematical interaction. The aim is to find a way of working which avoids making assumptions about what students mean by what they say. Analysis proceeds from looking at what participants attend to, to examine how they think together.

Introduction.

Although there has been considerable interest in the role of language in mathematics education, there is much less work which considers the teaching and learning of students who are still in the process of acquiring the classroom language. This paper concerns students in a UK primary mathematics classroom for whom English is an Additional Language (EAL) [1]. How do EAL students participate in the complex environment of the mathematics classroom? And how can this be investigated?

The literature contains much that relates to these questions, though little which addresses them directly. Several quantitative studies have used written instruments as a basis for comparisons between different language groups (e.g. Dawe, 1983) or to compare language proficiency with mathematical attainment (e.g. Cocking and Mestre, 1988; Clarkson, 1992). These outcome-based studies give little insight into learning *processes*. There has been a modest amount of work which examines interaction in multilingual mathematics or science classrooms (e.g. Warren and Roseberry, 1995; Moschkovich, 1996; Gibbons, 1998; Setati, 1999) although this work does not generally problematise the difficulties of making interpretations as an analyst in such culturally complex environments. More generally, there is a wider body of work which examines mathematics classroom interaction from different perspectives, examining such notions as mathematical communication (e.g. Steinbring, 2000), argumentation and the role of narrative (e.g. Krummheuer, 2000). As this work is typically based in monolingual classrooms, issues of cultural heterogeneity tend to be overlooked.

Complexity.

One of the aims of the research reported in this paper is to develop a methodology which does take account of students' cultural, linguistic and social histories in analysing data. On a substantive level, I am seeking to explore the nature of EAL

students' participation in mathematical interaction as they engage with tasks from their mathematics lessons. I am seeking evidence of what EAL learners *can* do in mathematical interaction, rather than conceiving of their language status as a barrier to be overcome. In this paper, however, the focus is primarily methodological.

In considering students' classroom talk, I start from the position that I cannot have direct access to students' personal, subjective meanings, since these meanings are related to students' "individual histories" (Bruner, 1996: 14), their unique social and cultural experiences. The individual experience of each student is a crucial part of how they make sense of the world around them, including the world of the mathematics classroom, since this experience entails the participation in and enculturation into patterns of language and behaviour, which in turn allow the interpretation and production of situated meaning (Bruner, 1990: 19). Given that EAL students in the UK come from a wide range of cultural, linguistic and social backgrounds and have often experienced life in several parts of the world, sometimes in difficult or traumatic circumstances, it is clear that it is unrealistic to assume that a researcher is in a position to understand students' interpretations.

The discursive psychology of Derek Edwards (1997) (also Edwards and Potter, 1992), which draws on conversation analysis and ethnomethodology, offers both a theorisation of language in use and a methodological approach to analysis with the potential to address the problem set out above. Language is conceptualised as primarily "a medium of *social action* rather than a code for representing thoughts and ideas" (Edwards, 1997: 84, original emphasis). Social action is foregrounded as the primary function of language, which is seen as having evolved through social interaction, and therefore as being structured both by and for social interaction. From the plurality of possible forms and modes of expression at any given moment of interaction, only one utterance can emerge. The path taken through this plurality of expression is determined by the social action and interaction of the participants. So for example, an utterance designed to persuade will take a different form from an utterance designed to attack, even if the 'content' is the same. The patterns of language through which these different actions take their form derive from each individual's experience of social interaction, their cultural and linguistic history. Thus, rather than attempting to analyse what students mean, discursive psychology seeks to examine how meaning is constructed and situated in discourse. Analysis of classroom discourse asks "not *what* do children think but *how* do children think" (Edwards, 1993: 216, original emphasis).

Discursive psychology also offers an approach to discourse analysis which emerges from the theorisation of interaction presented above. The process of analysis is based on the principle that language-in-use makes explicit that which participants are concerned with, and as a result, makes their interpretations available for analysts (Sacks, Schegloff and Jefferson, 1974: 728-729). Developing these ideas, Edwards and Potter (1992) outline five distinctive aspects of the discourse analysis of discursive psychology:

1. Analysis is of naturally occurring talk and prepared texts.
2. Analysis is concerned with the content of talk and its social organisation. This includes seeing talk as sequential and analysing utterances within the sequential context in which they occur.
3. Analysis is concerned with action, construction and variability. Different ways of talking are used in different circumstances and for different rhetorical purposes.
4. The rhetorical organisation of talk and thought is designed to counter potential alternative versions which may arise. The form of an utterance is determined by the action it is designed to perform, including the prefiguring of potential future courses of interaction.
5. It is the consideration of 'cognitive' issues such as intention or meaning in terms of how they are dealt with in discourse that leads to this approach being characterised as 'psychological'. The focus is on looking at how participants construct and rhetorically deploy psychological concepts in interaction. This is not to deny that people have intentions or meanings, but to argue (Edwards 1999: 272) that we can only examine how such notions are interactionally employed in different ways to suit different occasions and thereby accomplish different social actions.

In this paper I offer an example of this approach to analysis of interaction. First however, it is necessary to provide some context.

Research context.

I have been visiting the Year 5 (aged 9-10) mathematics lessons in a multilcultural urban UK primary school of approximately 150 students from a variety of cultural and linguistic backgrounds. In Year 5 (1999-2000) there were six students recognised as EAL. Initially I had hoped to record EAL students as they worked in order to obtain records of naturalistic interaction. I particularly wanted recordings of student-student interaction, rather than of the more heavily cued exchanges between students and the teacher. As classroom-based recording proved impractical the approach was modified: small groups of students were withdrawn from the classroom and recorded while they worked on a task together. Although not identical to classroom situations, the teacher frequently asks students to work together in this way. Furthermore, the task and the combinations of students selected were based on classroom observations. Thus although the interaction was not completely natural, neither is it particularly artificial.

The research design at this pilot stage was based around a topic about calculators. A task, that of writing addition word problems about money, was selected from the teacher's plan for the week. Six pairs or threes of students were recorded both before and after the calculator topic as they worked on the task. The primary data consist of fully transcribed audio recordings of the interaction. The analysis offered in this paper is of the first pair of students recorded before the lesson sequence. 'Cynthia' comes from a Cantonese speaking background and arrived in the UK about 18 months ago from Hong Kong, since when she has learnt virtually all her English. Her

English in Year 5 was assessed by the school as 'stage 2' on a 4 stage scale, where 'stage 1' indicates almost no proficiency in English. 'Helena' is an English speaking African-Caribbean student.

Interaction: extract 1.

Cynthia and Helena are working together on their first word problem. As with many of the recordings in the pilot study, Cynthia and Helena start by choosing a name for a character in the problem and then proceed with much negotiation to construct their problem. The result (see [2]) consists of twenty words and reveals little of their deliberations, as recorded in more than 70 lines of transcript. As noted above, it is possible to examine 'participants' concerns' (Sacks *et al*, 1974; Edwards, 1997) in interaction, as these concerns are made available for other participants, and therefore are also available for analysts. In this paper, I will show how an examination of *what* the two students attend to as they work together leads to insights into *how* they think together. Lack of space makes it impossible to reproduce a full analysis, including the fully transcribed sequence. I shall therefore use sections of the transcript to illustrate the approach (see [3] for transcription conventions; line numbers are indicated in the text in parentheses).

In the transcript discussed in this paper, Cynthia and Helena display two broad areas of attention. One concern is with the genre (or typical form; see Gerofsky, 1996) of word problems; the way they are constructed and the nature of the language they contain. They also attend to the mathematics of the problem which in this case is closely bound up with the requirements of the task. These foci are evident in the short extract below, which comes from near the beginning of the sequence:

Extract 1a.

56	H	Daniel um	*writes*
57	C	Daniel um	
58	H	went to the shop	
59	C	n-no can/ umm/ um write that/ Daniel **work**/ n-no/ Daniel/ w=um/	
60		Daniel/ well if he work/ (...) he have/ he have/ hundred pound/ and how	
61		many/ in/ the month/ (for example) like easy one	

As the students begin their discussion, they first attend to the general form, or genre (Gerofsky, 1996) of word problems, selecting a character (56-57) and a scenario for the problem (58-61). Cynthia offers a partial version of a problem (59-61). She then offers an evaluation of her problem, switching attention to the 'easiness' of her problem "like easy one" (61), so focusing on the mathematics and the task they have been set as she interprets it. It could be argued at this point that Cynthia's problem is deficient; she has not included enough information. Does this mean she does not 'understand' what a word problem should include? Or is it that she has a suitable problem 'in her head' but is unable to articulate it? These are not questions that can be answered from the perspective of discursive psychology. Instead, we should continue to follow the sequence of the transcript, examining what it is that the

participants themselves attend to. In this way it is possible to examine *how* thinking is *jointly* accomplished by Cynthia and Helena.

Extract 1b.

62	H	but you've got to use it in addin'/ addin'/ addition/
63	C	oh yeah
64	H	so you say Daniel/ yeah it's kind of like a addition thing isn't it/
65		because/ Daniel went to work/ he had hundred pound/ a month?
66	C	um/ a week
67	H	oh that's ^(okay then)^ a hundred pounds a week/ how many/ how
68		many um/ how ma=how much money do he have in a month
69	C	yep
70	H	(okay then)

Helena's initial response to Cynthia's offer (62) attends to the mathematical nature of what she has heard Cynthia suggest (which is not necessarily the same as what Cynthia thinks she has suggested), which is related to the task as she understands it. She states what is ostensibly part of the instructions "you've got to use it in addin'", so evaluating Cynthia's suggestion as potentially not 'addin' and therefore not compliant with the task. By using the form of words "you've got to" she carefully manages her implied criticism as being based on an external criterion and therefore as being less personal. Although apparently citing a 'rule', Helena's evaluation is situated and constructed in the context of the ongoing interaction, designed as a part of the students' social (inter)action.

Helena continues to focus on both genre and mathematics, but goes on to develop her interpretation of Cynthia's problem by reconstructing it as a potential addition problem (64-65). In doing so she identifies something that requires clarification: "a month?" (65); Cynthia has not stated how often Daniel gets his hundred pounds. Here Helena attends to the mathematics of the problem, as well as to the generic form of word problems, the two intersecting in her question, "a month?". In responding to Helena, Cynthia supplies an extra piece of information "a week" (66), thus taking account of the recent attention to the problem genre and the scenario-under-construction, as well as the mathematics of the emerging problem and the task in hand. Cynthia's response is not seen as an act of recall, providing a missing piece of information that was omitted in her original version but which was somehow 'in her head' all along. Instead, it is viewed as a situated response specifically designed for the moment of interaction in which it was used. This shows a highly sophisticated awareness of what is going on in the discussion with Helena.

This extract concludes with Helena reformulating the question that completes Cynthia's original problem, taking account of the preceding exchange (67-68). It is not possible to say here if this is what Cynthia originally intended, but that is to miss the point. The interaction shows Helena and Cynthia thinking *together* [4] as they generate their problem. It is not possible to separate the contributions of the two students. Although words and ideas can be superficially attributed to either Cynthia

or Helena, this is merely the result of the constraints of organised talk. They must take turns and speak one-at-a-time if they are to work (and think) together. Each contribution, however, must be seen as contingent on what has gone before, guided by the students' joint orientation to completing the task. Thus when Cynthia decides on "a week" (66), it is simplistic to claim that this is all Cynthia's idea, since it comes as a response to the previous discussion between both students, as well as an awareness of the potential future course of interaction.

Interaction: extract 2.

The above analysis shows how an initial focus on 'participants' concerns' (Sacks *et al*, 1974; Edwards, 1997) makes it possible to examine how thinking together is accomplished. Analysis of the rest of the transcript reveals similar insights. Extract 2 is taken from the last few lines of the transcript of the students' work on their first problem, which has evolved a little from the version apparently agreed on in extract 1. Prior to this extract, Cynthia and Helena have agreed on and Helena has written down: "Daniel has a job he gets pay £415 in a month". They are now negotiating the question which will conclude the problem.

Extract 2.

100	C	how many in a week/ no oh yeah/ how many in a week
101	H	(...) okay then/ how many/ how many/ how much money does he get/ in
102		a **year**/
103	C	in a week
104	H	a week?
105	C	no that's (...)
106	H	no cause/ you said in a **month**/
107	C	yeah/ no/ I said/ [no/ I said/ Daniel has a job he **gets paid** four &
108	H	[how many
109	C	& hundred and fifteen pound in a **month**/ how many in a **week**
110	H	how much he gets
111	C	yeah/ how-how much he get/ on one week
112	H	that's **dividing** innit
113	C	oh yes that's divide/
114	H	that's sort of like dividing cause there's four/ four weeks in a month so
115		that's **four** divided by (three) I mean four hundred and fifteen
116	C	I'll just do/ how many in a year// [(*inaud.*)

Cynthia suggests "how many in a week" (100). Helena responds with a reformulation, emphasising the key point of difference, " a year" (102), and thus revealing the two students' current concern. The detail seems important, since the choice between 'week' and 'year' affects the kind of problem they produce – either partitive or additive. Cynthia continues to attend to this choice, saying "in a week" (103). There is a sense at this point of both students being focused on this one detail, and so on the mathematics of the problem. The discussion moves forward through Helena and Cynthia trading "contrasting versions" (Edwards and Potter, 1992: 3) of what Cynthia 'said' (106-109), with the focus remaining with the choice between

‘week’ and ‘year’. In Helena’s version of what Cynthia ‘said’, she draws attention to a detail from the agreed on problem-so-far (now written down). By setting her version up as something Cynthia ‘said’, Helena explicitly links the choice between ‘week’ and ‘year’ with what has gone before. She is now attending to the mathematical structure of the emerging problem by looking at the relationship between ‘month’ and ‘year’.

Cynthia responds by also constructing a version of what she ‘said’ - another reformulation of the problem. In fact elements of her restatement were originally said by Helena (“gets paid” (107)), but again, the point is not to check Cynthia’s claim about what she said with what she actually said, but rather it is to look at what is accomplished by her claim, which has been constructed to suit the particular circumstances in which it was made. In this latest version, Cynthia makes a clear choice for ‘week’ in the context of Daniel’s “four hundred and fifteen pound in a month” (107, 109). Helena is then able to identify Cynthia’s version as “dividing” (112) and therefore, as in extract 1, implicitly not compliant with the task. It is noticeable that Cynthia now accepts this point quite easily and along with Helena’s earlier suggestion of “how many in a year” (116). It is *not* possible to say, however, that this is due to her mathematical understanding of the argument, or because of the persuasive nature of Helena’s rhetoric, i.e. because Helena is convincing, or because she just wishes to get the problem finished, or for any other reason.

Conclusions.

Analysis of what the students attend to as their discussion unfolds reveals two foci. Firstly, they attend to the form of the problem, both in terms of the generic ‘contents’ - such as a character and a situation - and in terms of the kind of language used (see 67-68), a feature more apparent in later sections of the transcript. Secondly, there is a focus on the mathematical nature of the problem as it emerges, a focus which is closely related to the task the students were set. These patterns, which are evident throughout the transcript, are an important feature of the interaction, as they enable Cynthia to think together with Helena. It is important to note that Cynthia *does* participate successfully in this discussion, a remarkable performance considering she has been learning English for less than 18 months. One way in which Cynthia and Helena are able to accomplish this thinking together is to use language to establish joint foci of attention. Cynthia is able to do this even at her relatively early stage of English language development.

Methodologically, the above illustration of the nature of analysis demonstrates the efficacy of the discursive psychology approach to discourse analysis. The broad interest in what the participants do rather than what they mean, makes it possible to examine interaction without needing to make assumptions about meanings or intentions. Thus in the first short extract discussed above, there was no speculation regarding Cynthia’s initial attempt to formulate a problem (59-61), which would clearly be difficult to make sense of. Instead the focus was on how her problem was constructed within the flow of interaction and how it was used in subsequent

discussion. The arguments and exemplification of analysis set out in this paper therefore demonstrate the possibility of analysing interaction in multilingual, multicultural settings without needing access to the languages or cultures of the participants.

NOTES.

1. English additional language (EAL) refers to any learner in an English medium environment for whom English is not the first language and for whom English is not developed to native speaker level. Native English speakers are described simply as monolingual.
2. The final written problem, typed but unedited except for the name, was: "Daniel has a job he gets pay £415 in a month. How much money does he get in a year?"
3. Bold indicates emphasis. / is a pause < 2 secs. // is a pause > 2 secs. (...) indicates untranscribable. ? is for question intonation. ( ) for where transcription is uncertain. [for concurrent speech. & for utterances which continue on a later line. ^ ^ encloses whispered speech.
4. Although the expression 'think together' has been used by Mercer (2000), my analysis does not draw directly on Mercer's work.

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