

RHETORICAL DEVICES IN MATHEMATICS CLASSROOM INTERACTION: SOLVING A WORD PROBLEM

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This paper contributes to the increasing body of work which offers detailed micro-analyses of mathematics classroom discourse. A discursive psychology perspective on discourse is adopted, particularly focusing on ideas concerning the rhetorical nature of social interaction. Four rhetorical discursive practices or devices are described. This framework is used to analyse a sequence of interaction in which a primary school teacher works with her class to solve a mathematical word problem. The analysis reveals the emergence of two narratives, one relating to the word problem, the other to the solution process. I conclude by drawing on my analysis to raise questions about the nature of mathematics classroom interaction.

INTRODUCTION

There is now a considerable body of research into the nature of mathematics classroom interaction (see, for example, collections in Cobb and Bauersfeld, 1995; Seeger *et al.*, 1998). This work largely draws on socio-cultural perspectives on the relationship between learning and interaction (e.g. Vygotsky, 1978; Wertsch, 1991, 1998; Bruner, 1990, 1996). Much of this work relies both theoretically and methodologically on notions of discourse. In this paper, I draw on a particular perspective on discourse based on work in discursive psychology (e.g. Edwards, 1997; Edwards and Potter, 1992). This work has developed a position on the relationship between discourse and the analysis of cognitive processes such as thinking, knowing or remembering. A key aspect of this approach is the idea language is used in different ways to do different social things, such as persuading, agreeing, disputing and constructing identities and relationships. In particular, much, if not all interaction can be seen as involving an element of persuasion; it is rhetorical in nature. The purpose of this paper is to consider some rhetorical aspects of mathematics classroom interaction. I will focus on a number of discursive practices or ‘rhetorical devices’ (Edwards and Potter, 1992) found in English language usage and show how this notion can be used to describe interaction in which a teacher works with her class on solving a mathematical word problem.

DISCURSIVE PSYCHOLOGY

Discursive psychology (Edwards, 1997; Edwards and Potter, 1992), drawing on concepts from conversation analysis (e.g. Sacks, 1992) and ethnomethodology (Garfinkel, 1967), sees interaction as primarily social. Interaction both constitutes and is constituted by, discursive practices which provide one resource for participants to act in and organise their social world. Psychological notions, including meaning, thinking and knowing are not examined as reified processes or mental states located inside people’s heads. Instead, they are explored as participants’ concerns (Edwards,

1997, p. 108; Sacks *et al.*, 1974), brought about and organised by participants through the discursive practices of their interaction. In the case of thinking, for example, the analytic focus is on how participants in interaction publicly construct and account for their thinking, through the stating of thoughts and ideas and accompanying justifications, explanations or rationalisations etc.

A key part of the discursive psychology view of interaction is the notion of *rhetoric*. Rhetoric concerns how interaction is put together in relation to the speaker's agency and responsibility or *accountability* (Edwards and Potter, 1992, pp. 165-166). Speakers design what they say to account for why things happened, why people acted in the way that they did, and in particular, the basis on which their claims are made. Thus, by designing their utterances in particular ways, speakers accomplish different outcomes, including, for example, the undermining of actual or potential alternative versions of what is being discussed (Edwards and Potter, 1992, p. 154; Edwards, 1997, p. 78). Rhetoric can therefore be seen as a function of interaction.

In examining how rhetoric works, a key question is 'what does this do?' What does a particular selection achieve that a potential alternative would not have achieved? What does a particular way of saying something achieve that a potential alternative would not? Thus, as well as examining how thinking, say, is publicly constructed, analysis considers how different constructions of thinking are used in different ways to suit different occasions and thereby accomplish different social actions (Edwards, 1998, p. 31). Analytically, one method of exploring such questions, is to examine the variation in talk. Participants routinely modify what they present as thoughts, ideas or attitudes and how they account for them. By examining and comparing these differences and the local contexts within which they arise, it is possible to uncover and describe particular discursive practices (Edwards and Potter, pp. 62-65; Potter and Wetherell, 1987).

In this paper, I will focus on some of the rhetorical practices available in the English language, practices which Edwards and Potter (1992) refer to as rhetorical devices.

Rhetorical devices

In developing the notion of rhetoric in discursive psychology, Edwards and Potter (1992, pp. 160-163) highlight a number of devices which are used to manage accountability, particularly in terms of supporting the veracity of a speaker's or writer's (I will simply refer to 'speakers' in future) particular stated version of the world. These devices work by either supporting the reliability of the speaker or by distancing the speaker from their account or version of the world, which can then be portrayed as 'objective'. I will focus on four of them.

Narrative accounts, characterised by Bruner (1990) as sequences "of events, mental states, happenings involving human beings as characters or actors" (p. 43), can be seen as doing rhetorical work within interaction. Bruner argues, for example, that one function of a narrative account of a particular situation is to resolve differences in interpretations of human behaviour by finding an "intentional state" (pp. 49-50)

which accounts for the behaviour at issue. Accounts which incorporate the roles of different participants, their motives and actions, and constructs a connected set of happenings, appear as more reliable (i.e. are more persuasive) than an incoherent set of observations. From a rhetorical perspective, interest in narrative accounts is focused on how such accounts are constructed in interaction, and in what is accomplished by constructing an account in a particular way (Edwards, 1997, p. 269).

Category entitlements implicitly draw on particular identities, or membership categories (Sacks, 1992, vol. 1, p. 40; see also Antaki and Widdicombe, 1998) which may be attributed to the speaker by a hearer and which are related to how reliable particular claims they make about the world may be taken to be. A lawyer, for example, may be expected to know things about the law. If a lawyer states something as a fact of law, they are more likely to be taken at their word because lawyers are 'entitled' to make such statements. If a biologist states a legal fact, they may be challenged to explain the basis of their statement, since biologists do not have the same entitlement.

Empiricist accounting entails the objectification of facts so that observers are removed or treated as recipients of information. The classic example of this style of rhetoric is found in scientific discourses in which scientists are portrayed as observing and recording objectively available facts about the world (Edwards and Potter, 1992, p. 162; Latour and Woolgar, 1986).

Logical argument or deduction draws on the idea that logical reasoning is objective and independent of the reasoner (see Edwards and Potter, 1992, p. 162, who use the term 'rhetoric of argument'). An argument that occurrence A is a logical consequence occurrence B is difficult to undermine. Whoever presents such an argument can claim that they have no personal interest and that the finding that B follows A is objective.

These different rhetorical devices are not exhaustive (see Edwards and Potter, 1992, pp. 160-163 for others); nor are they mutually exclusive. Interaction continually involves the use of many such devices, often in combination.

The business of teaching and learning mathematics, being conducted largely through the use of language, may be seen as a rhetorical process. It involves activities such as explaining, justifying, arguing, persuading, convincing and expressing ideas. Such activities are social in nature and entail the use of language to construct and organise the world of the mathematics classroom, including in part, mathematics. In the rest of this paper, I want to explore how some of these rhetorical devices may be used to describe mathematics classroom interaction.

RHETORICAL DEVICES IN THE MATHEMATICS CLASSROOM

In exploring the use of the rhetorical devices described above in mathematics classroom interaction, I will draw on data collected as part of a study concerning the participation of bilingual students in primary school mathematics in the UK (Barwell, 2002) (although I am not concerned with bilingualism in this paper). I have selected a

sequence from a transcript arising from this study. My purpose at this stage is to show some examples of the use of the above rhetorical devices in a mathematics classroom context in order to show what is possible within the discourse of such classrooms. I make no claims, therefore, about how prevalent the use of such devices might be. The sequence involves the teacher of a class of 9-10-year-olds. She has asked the class to solve a word problem which she has written on a flip chart. The word problem was written by some of the students on a previous occasion. The students' word problem is:

If Malik goes to the shop with £10 and spends his money on a drink 89p, some sweets (10 sweets costing 5p each) crisps (5 packets at 35p each) and pint of milk: 30p How much change will he have?

The sequence involves the teacher working on the problem with the whole class. An extract from near the beginning of the discussion is shown below (for transcription conventions, see [1]):

- 210 T so let's see/ if we can just work through this/ and decide
 211 what we've got to do/ to get the answer/ so we've got ten
 212 pounds/ what does he buy S12? (*Writes £10*)
 213 S12 um/ (he buys) a drink
 214 T which but hang on what does the drink cost/ S12
 215 S12 um/ eighty nine p.
 216 T right/ stop there/ what else did he buy Joanne?
 217 Joanne um/ some (sweets)
 218 T and how much did they cost
 219 Joanne five pence
 220 T right five pence each/ and how many did he buy/ Vicky?/ so
 221 what's the first thing we've got to do with that information/
 222 Cynthia?
 223 Cynthia five times ten
 224 T five times ten/ find out what the total cost of those sweets is/
 225 five times ten is what S13
 226 S13 forty p.
 227 T (*rolls eyes*) S13/ five times ten is
 228 S13 fifty
 229 T so already (...)/ then what did he buy Cynthia
 230 Cynthia um/ (*stands and reads*) he buy five packs of chips/

- 231 thirty five each/(the questions says 'crisps')
- 232 T right/ what do we do with **that** information S14/ you buy
- 233 five packets of crisps/ and they cost thirty five pence each/
- 234 what do you need to do with that information/

All four of the rhetorical devices described above are evident in the interaction between the teacher and students. First of all, the teacher sets up the task as 'working through' the problem and 'deciding what we've got to do to get the answer' (lines 210-211). What follows can therefore be seen as designed to carry out these tasks. Through the question-answer structure of the extract, the teacher constructs these activities as *narrative accounts*. Indeed she engineers two narratives, one relating to the content of the word problem, the other concerning the process of solving it. Thus, she uses questions which draw on the implicit scenario of the problem "what else did he buy", "then what did he buy". This narrativising rhetoric explicitly constructs a sequence of events involving Malik, which the class can discuss. This narrative 'gives' sense to the problem (Sharrock and Anderson, 1986, p. 56). The 'facts' of the narrative, however, are derived from the problem which is written on a flip-chart. These facts are treated as objective, drawing on an *empiricist* rhetoric. The teacher, through the question-answer pattern, invites the students to locate specific facts in the text and report them to her. One of the effects of this device is to transform a problem written by students in the class into a generic word problem. Although the information given in the problem was made up by some of the participants in the discussion, the agency of the authors is masked. There is no possibility, for example, of these students changing any aspects of their word problem. By objectifying their problem, the teacher freezes their ideas into something that can be solved but not altered. Treating word problems in this way is a recognisable aspect of the discourse of word problems (see Gerofsky, 1996).

As well as the narrative constructed from the word problem scenario, the teacher also creates a narrative of solving the problem. This narrative is at first implicit in the questions she asks the students concerning the content of the problem. It becomes explicit when the teacher asks "so what's the first thing we've got to do with that information" (lines 220-221), and continues, "find out what the total cost of those sweets is" (line 224). This narrative continues throughout the sequence, with the teacher alternating the focus of her questions from the word problem scenario narrative and the narrative of the solution process. This narrative serves to present an explicit, accountable solving process on the part of the teacher. Making thought processes explicit in this way, makes them available for other participants, who can hear the moves proposed and can accept or challenge them and offer alternatives. In this case, however, there is also a rhetoric of *entitlement*. The teacher, for example, guides the construction of both narratives through the questions she asks. These questions and the resulting narratives are accepted by the students; as a teacher she is entitled to work in this way. The students cannot, therefore, easily challenge the

reasoning that the teacher is offering through her questions and the resulting narrative of solving. They can only respond to the questions she asks. This asymmetry of entitlement is apparent in an exchange later in the sequence when the teacher invites a student to explain how she worked out a solution to the same problem:

- 301 S18 okay/ first of all I did eighty nine (add fifty) that equals
 302 T (*using calculator*) um a hundred and thirty nine
 303 S18 yeah/ a hundred and thirty nine/ then I added/ then I added/
 304 one pound seventy five to it/ then
 305 T three hundred and fourteen
 306 S18 (...)//
 307 T can I just stop you there
 308 S18 I done it all wrong

The teacher is able to interrupt the student's narrative account of her own solving process (line 307), which the student takes to be prefacing a criticism of her explanation (not actually the case). The student's response suggests that when a teacher interrupts a student, it is challenge or criticism which may be expected to follow, at least in this class. Such challenges are much harder for students to do to the teacher.

I have shown how the teacher uses questions to construct a narrative of solving for the word problem. This narrative also draws on the fourth rhetorical device, the *rhetoric of argument*. This device underpins most of the sequence. The teacher's questions concerning how the different items of information extracted from the problem should be combined is predicated on the logic of arithmetic relationships and their relation to the sense constructed for the problem. It may, perhaps, seem strange to portray the mathematics of the interaction as a form of rhetoric. Mathematics is after all the purpose of the lesson. Alternatives are nevertheless possible. When the teacher asks "what do we do with **that** information" (line 232), the students' responses, treated as acceptable by the teacher, implicitly draw on arithmetic logic. Students *could* respond that they would write down the information, ask the shopkeeper to work out the total, or just pay with a £10 note. By relying on the rhetoric of mathematical reasoning the participants contribute to the construction of the discussion as part of a mathematics lesson.

DISCUSSION AND CONCLUSION

The short analysis set out above describes how one teacher and her class work together on solving a single word problem and, implicitly, on solving word problems in general. I have illustrated how the four rhetorical devices described in this paper play a role in the sequence of interaction and have offered some indications of how these devices are used. In working on the word problem with her class, the teacher constructs two interwoven narratives, one concerning the word-problem scenario, the

other a narrative of solving. The use of these two narratives implicitly constructs a version of the process of solving word problems, involving first seeking and extracting information and then deciding what to do with it. Both narratives are largely constructed by the teacher, based on her entitlement as a teacher to ask questions and shape the construction of both problem and solution.

The different rhetorical devices which form part of the discursive practice of this class serve to manage the agency and accountability of the participants, carefully shaping, and perhaps limiting, the possible contribution of the students. More particularly, the construction through question-answer exchange of a narrative of solving, combined with the role of category entitlements, manages accountability and agency within the solving process. This analysis highlights the discursive practices through which the teacher, the students, the text of the word problem and various arithmetic operations and calculations are all related to each other in the development of a solution to the word problem.

By focusing on rhetoric as a basis for analysis, it becomes possible to ask how else agency and accountability could be managed? One feature of the above sequence, for example, was the construction of some aspects of the word-problem task as objective. Would it be possible to construct these aspects in a different way, so that they are *not* seen as objective? The device of empiricist accounting, for example, rendered the students' word problem fixed, generic. What happens if word problems are treated less 'empirically'? Similarly, the extract used above displays particular category entitlements relating to who can ask certain kinds of questions, who can challenge, who can interrupt. Having highlighted such patterns, it is possible to consider how such entitlements could be changed. Perhaps alternative categories would need to be deployed, or perhaps the entitlements of the categories used could be modified. My analysis particularly highlights the narratives which the participants construct. Narratives, by design, present an account as a unique sequence of events. Thus both the solving process and the interpretation of the word problem that emerge in the above extract, are constructed as unique. This analysis therefore raises the possibility of alternative narratives of solving or concerning the word problem.

In this paper, I have introduced the notion of rhetorical devices and described four such devices found in English. I have shown how this concept can be used to describe interaction in the mathematics classroom. My analysis of an extract in which a teacher works with her class on solving an arithmetic word problem shows how rhetoric works to construct an accountable solution within an objective mathematics.

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NOTES

1. Transcription conventions: Bold indicates emphasis. / is a pause < 2 secs. // is a pause > 2 secs. (...) indicates untranscribable. ? is for question intonation. () for where transcription is uncertain.

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