CUMULATIVE AND EXPLORATORY TALK IN A COLLABORATIVE LEARNING CLASSROOM

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This paper describes an approach to the analysis of talk within small groups of students working on mathematical tasks. Two typical ways of talking and thinking are identified: cumulative talk and exploratory talk. An example of each type is given, using data from a study of a Year 10 class. Changes to the nature of the talk when the teacher is present are also reported. The focus is on both the content of the talk and the interactions in the group.

INTRODUCTION

This paper reports work in progress on a study of student-student interactions during collaborative learning activities, that is, when students are working on shared tasks, with a common goal, and for most of the time independently of their teacher. I am interested in the social construction of mathematical competence and ways in which student gender interacts with this. I have chosen to focus on students at the stage where they are beginning calculus, because this is when they make key course choices which affect their post-school options and their future relationship to mathematics. These choices are predicated on students' evolving perceptions of themselves as learners of mathematics.

For the purpose of the main study I needed to find ways of analysing student-student talk, describing group processes and identifying those which may affect both the knowledge constructed by the students and their perceptions of themselves as learners. I have made use of the work of Mercer (1995) who identifies three typical ways of talking and thinking among students working in small groups: *Disputational talk*, characterised by disagreement and individualised decision-making; *Cumulative talk*, in which speakers build positively but uncritically on what others have said; and *Exploratory talk*, in which the participants engage critically but constructively with each others' ideas. In this paper I describe key characteristics of the different types of talk in the classes I observed, and discuss the roles of teacher and students in producing them.

ANALYSING TALK WITHIN STUDENT GROUPS

Research on classroom talk has tended to focus on interactions between teacher and students in whole-class learning situations. Until recently, student-student interactions were studied to a much lesser extent. Much of the research on peer interactions, especially in the USA (Webb & Palincsar, 1996) has had a process-product focus, categorising utterances such as asking questions, giving explanations, and so on, and using quantitative analysis techniques. Research in Britain has more often adopted a qualitative approach. A major influence was the work of D. Barnes and Todd (1977). Initially these researchers planned to use a quantitative approach, but abandoned the attempt because they found that the linguistic form of an utterance frequently did not match its function, utterances frequently seemed to belong in several categories, meanings were fluid and changing in response to on-going events in the conversation, and "the features the observer focusses on as being most significant are precisely those which are hardest to categorise in a reliable way" (D. Barnes & Todd, 1977, p. 17).

Analysing talk within small groups of students is not easy, because it is much less structured than teacher-led talk. As D. Barnes (1992) observes, in a teacher-led discussion the teacher decides what is relevant to a topic, how much will be said about it, and what answers are acceptable. The teacher in general also decides who will talk, when and for how long. In small group discussions, these tasks have to be accomplished by the students themselves.

They must make their own judgements about what is relevant and what is "correct", and they must also organise turn-taking. These two facets of a discussion are not independent—the same utterance may serve several functions. For example, a student reading out a question from the worksheet initiates a new topic for discussion, but this may also be interpreted as a bid by that student for the attention of the group, and perhaps even as an attempt to exert control over the group process.

To take account of this complexity in talk between students, D. Barnes and Todd (1977) distinguish between two frames of reference: 'content' and 'interaction'. As Edwards and Westgate (1987) point out, the content frame is concerned with what the group are talking about, their ideas and logic. Within this frame, the participants provide evidence of what they think (or what they want the others to believe they think). The interactional frame is concerned with how the group relate to one another. Within it, the participants provide evidence of their attitudes to one another and the relationships between them. During a group discussion, there is simultaneous interplay between these two frames.

Various schemes have been devised to categorise the content of talk. Thomas (1994) divided talk within groups into non-task-related and task-related talk. Task-related talk was divided into social (or managerial) and cognitively-oriented. Finally, cognitive talk was divided again into action (dealing with the task at hand) and reflection (dealing with explanations and understanding of ideas). A broadly similar scheme was proposed by Pirie and Schwarzenberger (1988). In view of the difficulties of categorisation noted by D. Barnes and Todd (1977), however, such schemes may be of limited value. It is better for analysis to focus on the sequence, and how the individual turns depend on one another. Similar arguments apply to coding the interactional aspects of a discussion.

To study disputational, cumulative and exploratory talk, it is therefore necessary to look at excerpts of talk larger than individual turns. The description of the structure of a lesson given by Clarke and Helme (1997) is useful here. They consider a lesson as consisting of a number of episodes, each defined by a consistent goal such as the solving of a particular problem. An episode is composed of one or more negotiative events associated with identification of, and attempts to resolve, a sub-goal. Negotiative events may be initiated by an expression of uncertainty, like asking a question. In many cases, however, the question is not explicitly stated, but is implicit in the students' actions. A negotiative event may be quite lengthy, or consist of only one or two turns.

METHOD

The data reported here are drawn from an ethnographic study of a Year 10 mathematics class in an independent coeducational school in a major Australian city. This class was chosen for the study because of the teacher's interest in, and experience in using, collaborative learning methods. A series of lessons was videotaped, and whenever the students were working in small groups, the camera was trained on one of these groups. Transcripts of the videotapes were prepared, including descriptions of actions, gestures, facial expressions or voice intonations which were judged to be relevant. Although the data gathered also included interviews, field notes, student worksheets, and other materials, the discussion here is restricted to portions of the videotapes and the transcripts which record small group discussions.

The first stage in analysing a transcript was to subdivide it into episodes and negotiative events, as defined by Clarke and Helme (1997). The transcripts were then coded for the *content* of the talk using an adaptation of the scheme devised by Thomas (1994). That is, utterances were classified as non-task related talk, task-related social talk, task-related cognitive action talk, and task-related cognitive reflective talk. A study of the coding revealed that the character of the talk tended to be generally consistent within an episode. The consistency of the goal within an episode appears to result in consistency in the pattern

of talk. Within each episode, other features of the talk were noted, such as repetition, contradiction, interruption, and completion of a sentence by another speaker.

Study of the *interactional* frame made use of aspects of the exercise of power identified by M. Barnes (1998). These included initiating a negotiative event or non-task talk; rejecting or ignoring an attempted initiation; claiming the attention of the group by interrupting another, or by use of gesture or emphatic speech; introducing, rejecting or accepting a suggestion; and handing over control of the discourse by passing a worksheet or other essential resource to another student.

The shift from one episode to another is characterised by a change of goals—the task on which the group is working may change, and the teacher may be absent or present. These changes influence both the content and the interactional patterns of the talk, and hence the level of talk (disputational, cumulative or exploratory).

My main interest is in the exercise of power within collaborative groups, as this may be relevant for the study of gender effects. The interaction frame in particular may illuminate attempts to dominate, control, or influence the group process.

ANALYSIS

The data analysed so far contain no episodes of disputational talk. Occasional pairs of turns in which one student contradicted another without giving an explanation are better described as part of cumulative talk. It was clear on these occasions that the first student had made a slip, and realised this when attention was drawn to it. No explanation was given, because none was needed, as everyone tacitly acknowledged the correction.

Episodes 1 and 2 below show examples of cumulative and exploratory talk respectively, while Episode 3 illustrates the effect of the teacher's presence on the group interaction. All are chosen from the same lesson, and relate to the same group of three students.

An explanation of notation used in the transcript is given below:

Symbol	*Meaning*
—	interruption by another person
-	self-interruption
//	simultaneous speech
(...)	indecipherable utterance
(what)	the best guess for an indistinct utterance
[ ]	observations from videotape or field notes

Episode 1: An Example of Cumulative Talk

1. Selena: How do you write a relationship for this? [Mike leans forward to look, as Selena points to the worksheet.]
2. Mike: T varies, (T equals) one over n. [Jacqui writes.]
3. Jacqui: What's happening is T varies as one on n.
4. Mike: T inversely as n. [reading from worksheet] Calculate T equals five, T equals ten, T equals twenty. [Selena nods]
5. Mike: Although - oh yeah, that's right. Oh golly. So T equals k over n.
6. Jacqui: [writes] And then all you've got to do is substitute //the values in
7. Mike: //one of them in, and find the k.
8. Jacqui: What?
9. Mike: Find the k.
10. Jacqui: Yeah. So you've got to - What numbers is she going to put in?
11. Mike: Sixty and nine, twenty and um [pause]
12. Jacqui: Is that equal? [Gets out ruler, leans over worksheet to measure accurately.] Thirty and ten.
13. . . . [Brief interruption - talk about what another group is doing]
14. Mike: Here we go. So we've got, thirty and ten.
15. Jacqui: Thirty and ten. This is the n. So if we substitute ten for it, it will pass //through thirty
16. Mike: //So the time is - Yep.

17. Jacqui: equals k on—
18. Mike: ten.
19. Jacqui: ten.
20. Mike: k equals, three hundred?
21. Jacqui: [pauses to think] Yep. Okay, so k equals three hundred.
22. Mike: So we've got T equals three hundred over n, is our equation?
23. Jacqui: Yep.

Content: Nearly all of this episode was directly concerned with the task at hand—finding the equation of the graph. The only exceptions were the brief off-task interruption (13), not given in detail here, involving talk about what another group was doing, and Mike's "Here we go" (14) which brought them back to the task (coded as task-related social). The talk progressed steadily towards finding the equation. Mike and Jacqui spoke confidently: "What's happening is ..." (3) and "All you've got to do ..." (6). At no stage did they go back over what had already been done. Selena, however, took no part in this episode other than to ask the initial question. She was new to the class at the time of this lesson, and the ideas and techniques of inverse variation were unfamiliar to her.

Interaction: This is a good example of cumulative talk. Each participant in the discussion was building on what the other said and neither played a dominant role. They frequently repeated what the other had just said (14, 15 and 20, 21) or paraphrased it (2, 3, and the first part of 4). On occasions, one completed a sentence begun by the other (6–7 and 17–18) which is a form of affirmation. There were numerous expressions of agreement but at no point was there any disagreement.

Episode 2: An Example of Exploratory Talk

24. [Mike hands the worksheet to Jacqui. She turns it over, and sees what is on the other side.]
25. Jacqui: Oh. [Reads] "Explain what is happening in question three and why." [turns the paper over again to look at the question on the first side, looks at the others, sits back]
26. Jacqui: Like — [gestures as if to say "what does that mean?". Selena laughs.]
27. Mike: — Like you're taking away two and they're becoming negative, I don't know?
28. Jacqui: ( )
29. Selena: Just uh —
30. Jacqui: — You're taking away //the time
31. Selena: //time, from the time.
32. Jacqui: You're taking away the number of workers by the time and then minusing it from something else.
33. Mike: It's the time for a certain //amount of workers
34. Selena: //Time take time —
35. Mike: — minus the time for a certain other amount of workers.
36. Jacqui: [picks up her pen and begins to write.] So it might be taking away.
37. Mike: Do they mean what is happening with the answers or just the questions?
38. Jacqui: [Reads from sheet again] "Explain what is happening in question three and why."
39. Mike: Yeah, yeah.
40. Jacqui: And then what does it mean. Yes, okay. It's taking—
41. Selena: —It's the difference of time.
42. Jacqui: [to Selena] Like, the number of workers multiplied by the time.
43. Mike: Taking away the number //of
44. Selena: //the time of a certain —
45. Mike: — Yeah, the time for a certain —
46. Selena: — for a certain number of workers from uh, the time for a certain number of workers. [Selena looks to Mike and smiles. They use similar hand gestures to emphasise what they are saying.]
47. Mike: We know what we mean.
48. Jacqui: [pause while she writes down the answer] workers from //blah blah, the same thing.
49. Selena: //Another certain —
50. Mike: — Another certain amount of workers.

Content: Here, the students were focused on the task all the time—there was no off-task talk, and organisational matters were managed without the need to talk. As they struggled to make sense of the question and find an explanation, their talk was nearly all reflective. At the start they all seemed unsure of what was wanted. They spoke hesitantly as they

sought for words to explain their ideas, and occasionally used gestures to help them. Uncertainty was expressed in gesture and tone of voice (26) as well as in words, such as "I don't know" (27) and "it might be" (36) and by direct questions "Do they mean ..." (37). The discussion did not move forward steadily, as in the previous example. The group several times went back again over what they had already said—for example, they re-read the question in an attempt to understand what was wanted. Statements made near the beginning were repeated later on.

Interaction: At the start, Mike handed over the role of manager and scribe to Jacqui by passing her the worksheet. By hesitating, Jacqui (26) and then Mike (27, 37) gave others a chance to speak. Occasionally they completed one another's statements (as in 30-31), but later Mike persisted with what he was saying despite interruption (33–35 and 44-46). In places one or more of the students corrected a mistake. For example, Jacqui's statement (32) was corrected by Selena and Mike (33–35) and Mike's statement (43) was corrected by Selena (44). At this point in the lesson, Selena appeared to be more confident than the others—she did more interrupting, correcting and explaining. Compared with the previous episode, the difference in Selena's participation warrants further examination and explanation.

Gesture seemed to be more frequent in exploratory talk. The students were less certain about the ideas they wanted to convey, and were groping towards ways to express them. In such circumstances, they may have found words inadequate to express their tentative thoughts, and supplemented them with gestures (see Reeve and Reynolds, 1999).

Episode 3: The Effect of the Teacher's Presence

51. Mike: [Teacher joins the group] Miss _____, this is pretty challenging, I've decided.
52. Teacher: What've you got?
53. Jacqui: [gesturing towards another group] They haven't even got the equation.
54. Selena: Five. [She and Mike are completing the last part of question 2.]
55. Teacher: Did you get the equation?
56. Mike: Oh yeah.
57. Jacqui: We think we got it.
58. Teacher: So what's happening here, with these values?
59. Mike: //(...)
60. Jacqui: //They're decreasing as the, [points to graph] that increases —
61. Mike: — You see this —
62. Jacqui: — in other words, like that — [gestures again]
63. Mike: — this is a realistic graph because it's actually not going to cut the axes —
64. Jacqui: — so as n increases, T decreases, which sounds right.
65. Teacher: So what would happen if I had, six thousand workers?
66. Jacqui: It would be taking not very time - not very much time.
67. Jacqui: Well, it may not be realistic, because, like, the problem isn't defined because it's like ten workers planting one tree, or ten workers planting ten trees. So it could cause complications if it works out technically.
68. Teacher: So just give me an interpretation of the general trend here, what's happening?
69. Mike: Well, as, as —
70. Jacqui: — It starts off being —
71. Mike: — T increases, n decreases, so it's inverse variation.
72. Teacher: Okay, fine, and [pause] these differences here, some of them are approximately the same, like the difference between twenty and thirty is ten and between thirty and forty is ten. Whereas these ones are not the same, like - as they were before. Can you try and um, // work out why?
73. Jacqui: //It's because it's not a straight line, it's not actually like as one varies as one and two and two and three [gesturing with pencil in the air] it's got a curve to it.
74. Teacher: Okay, very good. All right, can you fill out the rest of it, and turn and look over the other side. Oh, you, you're pretty much doing that?

Content: The teacher's interaction with the group changed the nature of the talk. Up to this point in the lesson, the group had found the task routine and had been working through

it in a straightforward manner, without need for explanation or reflection. The teacher's questions prompted reflection, and in particular thought about the possible real world interpretation of the model they had been investigating. This helped to establish the discussion at a more exploratory level.

Interaction: There are features of the interaction of teacher and students in this informal setting which would be rare in whole-class discussion. Mike, not the teacher, initiated the discussion, and he did so by making an ironic remark (51). Then the teacher's question (52) was largely ignored—Jacqui talked about the progress of another group (53) while Mike and Selena finished off what they were working on (54). The teacher had to re-phrase and re-focus her question (55) to get a response. Finally, Jacqui interrupted the teacher (73), beginning to answer the question before the teacher had finished. Thus the small size of the group permitted an informality that would be unusual in whole-class teaching, and to some extent served to counteract the powerful role of the teacher.

On the other hand, as the episode progressed it began more and more to resemble the traditional Initiation-Response-Evaluation (I-R-E) pattern characteristic of classroom talk (Sinclair & Coulthard, 1975). The teacher initiated nearly every negotiative event (52, 55, 58, 65, 68, 72) and towards the end evaluated the responses before continuing (72, 74). It is clear that the presence of the teacher completely altered the dynamics of the interaction. Jacqui and Mike appear to be competing with one another to gain the teacher's attention. In her presence, their goals no longer are to complete the task they have been set, but to impress their teacher with what they understand. Jacqui (60, 62, 64) wanted to make one point, and Mike (59, 61, 63) had something different to say. Each persisted, in spite of being interrupted several times by the other. The same began to happen again in 69–71, but Mike gained the floor and the teacher accepted his explanation, so Jacqui did not have a chance to complete what she began to say. At the next opportunity, Jacqui interrupted the teacher to get her response in first and demonstrate her understanding (73). It is noticeable that Selena took no part at all in this competition for attention.

DISCUSSION

The absence of disputational talk may be a consequence of the maturity of the students (a Year 10 class studying an accelerated mathematics course) and the care which the class teacher had taken to train the students in group work, making clear her expectations that they would listen to and value other people's contributions, and explain and justify their own assertions.

What Outcomes May We Expect from Cumulative Talk?

In cumulative talk, as we have seen, students generally have the satisfaction of success. They find that they agree with their colleagues, and confirm and validate one another's statements. We may expect this to result in the affective outcomes of reassurance, increased confidence and rapport within the group. Another expected outcome is the consolidation of material already learned. Cumulative talk is generally the result of students working on tasks that they can achieve without much hesitation or uncertainty, so it is unlikely that they will be dealing with material that is unfamiliar, or constructing knowledge that is really new to them. At least in mathematics, a high incidence of cumulative talk may be a sign that the tasks set are not challenging enough. While such tasks may have the positive outcomes described above, and may also be stepping stones to more demanding activities, they should not be used too frequently.

What Outcomes May We Expect from Exploratory Talk?

Usually we would expect exploratory talk to lead to the generation of new knowledge and understanding. Mercer (1995) argues that in planning collaborative activities in the mathematics classroom, we should be aiming to promote exploratory talk:

> Exploratory talk, by incorporating both conflict and the open sharing of ideas, represents the more 'visible' pursuit of rational consensus through conversation. More than the other two types, it is like the kind of talk which has been found to be most effective for solving problems through collaborative activity. (Mercer, 1995, p. 105)

If exploratory talk is successful, it achieves important positive goals, but if it is unsuccessful it may create frustration and generate negative attitudes. It is important, however, not to be too quick in deciding that exploratory talk has not resulted in the generation of new knowledge—the first outcome may be to spur students to think more about the problem or topic, leading to later valuable breakthroughs.

CONCLUSION

The approach described above appears to be an effective way of dealing with the complexity of classroom talk. The consistency of type of talk observed within episodes suggests that the flow of classroom events may effectively be described at this level. This may prove to be a useful technique for data reduction where there are many transcripts to be analysed. At the same time, the possibility of looking in more detail at events occurring within an episode is always available. This paper has identified some key features of exploratory and cumulative talk which will be used in later analysis.

The value of this approach is demonstrated by the fact that it has permitted observations of specific factors which may tend to encourage or support exploratory talk. The examples given above demonstrate the key role played by the teacher in collaborative learning. Carefully chosen teacher questions, either asked in person, or incorporated in the written questions on the worksheet, can have the effect of shifting the talk from cumulative to exploratory. Teachers, however, need whenever possible to pose a question and then move away, leaving the students to think about it, rather than risk being drawn into an evaluative role which removes responsibility from the students.

Questions posed by thoughtful students can also provide a spur to exploratory talk. But for this to happen, the students need to be encouraged to listen carefully to other people's questions and take them seriously. It may also be important to encourage students to think about what reflective or exploratory questions they can ask.

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