Groupwork with Multimedia in Mathematics: contrasting patterns of interaction

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Introduction

This paper outlines the way in which the NCC multimedia package 'W orId of Number' was used as the focus for a group activity with a Year 9 mathematics class. The classroom research was carried out in a South Yorkshire comprehensive school during the Spring Term of 1994. The class was engaged in work which involved graphs of relationships and close attention was paid to relationships between distance, speed and time in a variety of contexts.

The resulting classroom activity will be illustrated with reference to some examples of the discourse from three of the groups working on the multimedia-based activities. The framework for analysis of the classroom discourse is outlined which is based upon a Vygotskian perspective. As a result of this study, the focus of attention has shifted from classroom collaboration to classroom interaction, for reasons which are outlined.

Background

The group involved in this project was a Year 9 top set 1 of approximately thirty pupils. The project was designed to fit in with the planned scheme of work for the Spring Term of 1994 when the group was due to do a unit of work on graphical interpretation involving graphs of motion. The overall plan was based upon the theme of graphical interpretation and the aim was to integrate activities both on and off the system with aspects from the planned scheme of work over a two week period.

The topic was introduced as a whole class activity, more fully detailed in Hudson (1994), and in the following lesson the unit Running, Jumping and Flying was introduced to the whole class with the aim of setting the context and giving the pupils a sense of what to expect in terms of the future activities on the system. The chosen element was the women's 100m race in the Seoul Olympics. Following this whole class introduction some groups began working on the activities at the system. A group size of three had been agreed with the class teacher, with the aim of creating the conditions for effective interaction. Each group was allocated an initial period of thirty minutes for intensive work at the system. The practical limitations were eased considerably by the use of two systems. In addition to the original laser disc package the school also had the use of the CD ROM version. This provision enabled four groups to carry out the multimedia-based activities in a one hour lesson and for each

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group to have a turn over the period of a single week. The class was timetabled for two lessons of approximately one hour and one of half an hour per week.

Multimedia-based activities

The main aims of the multimedia-based activity were to promote discussion and require time for reflection which was consistent with one of the preliminary findings of the NCET evaluation, as reported by Hughes (1994), of the need for "reflective moments". The activity was structured in such a way as to encourage the following process: select and view a video sequence, think about the distance-time graph, sketch the graph, compare graphs, choose a graph which fits your ideas, explain to each other why a particular graph does or does not fit, test out choice on the system and finally repeat the process with a different choice of axes. This can be summarised as a cycle of observation, reflection, recording, discussion and feedback, as illustrated in Figure 1.

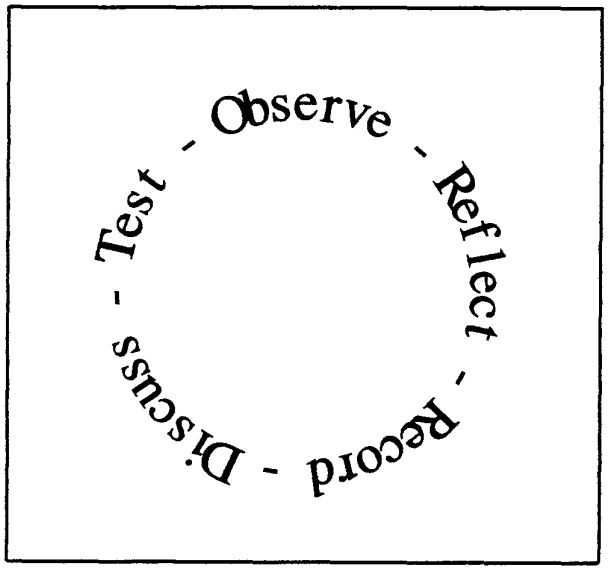


Figure 1

Once the group had worked through a sequence following this process, they were asked to pass over control of the system to another member of the group and to repeat the cycle with another sequence. A follow-up group activity was designed around the task of a joint poster display to illustrate at least three of the video sequences and the associated graphs of relationships between various variables.

Framework for analysis

The approach to the analysis of the classroom discourse was particularly influenced by the work of Mercer (1991) and that of Teasley and Rochelle (1993). The focus of the study reported upon by Mercer is the content and context of educational discourse from a theoretical perspective strongly influenced by the work of Vygotsky (1962). He describes the analytic methods adopted as being similar to those of ethnography, "in that we were similarly concerned with the minutiae of what was said and done; and we were interested in participants' accounts and interpretations of what they said and did". The method employed by Mercer involved the complete transcription of all the discourse recorded on videotape. **In** addition, any information on the physical context and non-verbal communication, which was necessary to make sense of what was said or done, was added alongside this relevant section of the transcript. This information is described as context notes which might include reference to the physical 'props' of the classroom, such as equipment, drawings, texts and computer-screen representations invoked by speakers to support the discourse.

In reflecting upon the approach to the analysis of the video tape transcripts the need for a framework for the analysis of the data soon became evident. The approach adopted by Teasley and Rochelle was found to be particularly resonant and was consequently adapted to form the chosen framework. Teasley and Rochelle report on a study which is intended to illustrate the use of the computer as a cognitive tool for learning that occurs socially. The study is concerned with the question of how students construct shared meanings in relation to modelling activities, in the context of a Newtonian microworld. This microworld is a computer package which is described as "a graphical and dynamic simulation of a physicists' mental model of velocity and acceleration". They outline a view of learning which is in the tradition of Vygotsky, in that it is based upon a view of learning as a fundamentally social activity i.e. that understanding is built through social interaction and activity and that concepts and models are social constructions resulting from "face-to-face participation" in activities.

A framework for the analysis of collaboration is outlined, which the authors argue involves not only a microanalysis of the content of students' talk, but also how the pragmatic structure of the conversations can result in the construction of shared knowledge. **In** order to understand how social interaction affects the course of learning, Teasley and Rochelle argue that it requires an understanding of how students use coordinated language and action to establish shared knowledge, to recognise any divergences from shared knowledge as they arise, and to rectify any misunderstandings that impede joint work.

Joint Problem Space

The notion of 'a shared conception of a problem'"is a central one and this is used as the basis what is described as a Joint Problem Space. It is proposed that social interactions in the context of problem solving activity occur in relation to a Joint Problem Space UPS). This is defined as a shared knowledge structure that supports problem solving activity by integrating the following:

a goals

b descriptions of the current problem state

c awareness of available problem solving actions

d associations that relate goals, features of current problem state and available actions.

This idea is developed further with the proposition that the fundamental activity in collaborative problem solving occurs by means of the engagement of the participants in an emergent, socially negotiated set of knowledge elements that together constitute a JPS.

A number of "structured discourse forms" are described which conversants use in everyday speech to achieve mutual intelligibility. These utilise language, bodily action and combinations of words and actions. It is proposed that students use the structure of conversation to continually build, monitor and repair a JPS. They also describe some categories of discourse events that they have used in their analysis such as turn taking, narrations and coordinations of language and action.

Analysis of video tape transcripts

The initial viewing of the video recording of the multimedia-based small group work confirmed the impressions of collaboration and rich interaction, which were formed during the course of the classroom trials. However this was mixed with evidence of lower levels of collaboration and some quite superficial interaction. Extracts from the work of two groups are presented in this paper as examples of contrasting patterns of interaction. The first of these is made up of Laura, Chantel and Claire who provide evidence of collaborative interaction and joint problem solving activity. In contrast, the second group comprises Joanne, Caroline and Vicki, whose interaction is analysed to provide an example of a less successful collaborating group.

Where an extract from an episode has been used in the text, each utterance is numbered in order, from 1 onwards, in order to facilitate cross referencing. Where the group members were interrupting each other or speaking simultaneously their contributions have been marked with a continuous vertical line immediately to the left e.g. | N:

Laura, Chantel and Claire

Group 1: Laura, Chantel and Claire
Episode 5: Cheetah (0.14.16)

1	L:	Do one that you want, cos like, well I did one.	Laura speaking to Chantel.
2	Ch:	Do Cheetahs. What do you two want?	
3	Cl:	Cheetahs.	
4	Ch:	Great. Play it.	
5	Cl:	Oh, speed against time.	

6	Ch:	Play it.	
7	Cl:	Play it.	
8	Ch:	Should we start on there? When it's cleared. Distance?	Bottom left hand corner of the screen.
9	Cl:	Is it distance against time we're doing?	
10	Ch:	Yeh, distance against time.	Sketching graphs.
11	L:	So it's starting off no distance and time.	Pointing to the origin. 
12	|Ch:	It goes - it gets faster.	
13	|L:	That's right.	
14	|Ch:	It'll go up like that, won't it?	
15	Cl:	Try that.	Up to this point Claire had been active in sketching the graph but did not take a turn from line 10. At this point the computer provided "correct" feedback and the full screen replay with graph overlay was played.

Figure 2

In this episode Laura, Chantel and Claire have established the means for interacting with the multimedia system and also the nature of the task set. Laura initiates this episode at line 1 by inviting Chantel to make the choice on this occasion. The turn taking between Chantel and Claire then flows smoothly down to line 11, although there is a significant gap between line 8 and 9 where they all appear to be thinking and sketching graphs. This section of the discourse relates to establishing the problem or JPS and setting the appropriate parameters on the computer system. Laura, who has been active in sketching her graph up to that point, then makes her suggestion that it's starting off "to distance and time", whilst simultaneously pointing to the origin of the graph shown on screen. Given that, of the two available graph options, this is the only one to go through the origin, Laura has drawn the attention of the group to this crucial distinction between the two options. This is accepted by Chantel, who offers another feature of the motion at line 12 by stating that "it gets faster". Although not directly relevant, it is almost instantaneously accepted by Laura and leads Chantel to complete this collaborative interchange with the question at line 14 that "It'll go up like that, won't it?" Before Laura has a chance to respond, Claire takes her turn to accept the analysis of the others by suggesting "Try that". Up to this point Claire had been concentrating on drawing her graph, having established the nature of the problem at line 9. However it would seem that she had been attentive to the interaction between Chantel and Laura, given the timing of her final contribution which brought the episode smoothly to completion.

In the next section they are considering the graph of speed against time.

Group 1: Laura, Chantel and Claire
Episode 5: Cheetah (continued)

16	L:	Speed against time.	
17	Ch:	Speed against time.	
18	L:	So speed ...	
19	Ch:	It'll go up again, won't it? Like that.	Showing her sketch to the others.
20	Ch:	No! No! No! No! No!	Mistake made in sketching the graph - talking to herself.
21	L:	That were it.	Referring to the second graph option.
22	Ch:	Well he'd already started off speeding - hadn't he? He was slowing down, wasn't he? Like that.	
23	Ch:	Aye, like that!	Referring to the selected the graph.
24	L:	Yeh, test it.	
25	Ch:	Or that one.	
26	L:	Test that one!	Back to the initial choice above - sounds certain.
27	Ch:	He were already running, weren't he?	
28	L:	Yes!	Positive feedback received from the system.

Figure 3

In this second section of the episode Chantel interrupts Laura to make the first suggestion at line 19 that "It'll go up again won't it? Like that". At the same time she shows her sketch to the others inviting acceptance or repair. Before anyone else responds she takes the opportunity to repair her own understanding, as she realises that she has made a mistake, and at line 20 answers herself with "No! No! No! No! No!" This leads Laura to suggest the graph on screen as being appropriate. Chantel's response at line 22 provides an explanation for the graph being the shape that it is - she reasons that "he'd already started off speeding" and that "he was slowing down". At this point it is clear that Chantel is engaged with the problem and has followed the guidelines of the task in sketching the graph and in justifying her ideas. It is also the case that all the interactions in this second section are solely between Chantel and Laura, with Claire not participating in an active way.

A particular feature to emerge from the analysis of this data is the pattern of Chantel's utterances. It would seem that Chantel is instrumental in giving a lead to the collaboration throughout this episode, by the way in which she combines her assertions with a question inviting acceptance or repair. Over the course of this episode Chantel asks seven out of a total of eight questions which are posed. Of

these five are of the form "wasn't he" / "won't he" etc and are linked to a preceding statement. For example at line 22 she offers two statements with questions attached:

Well he'd already started off speeding - hadn't he?

He was slowing down, wasn't he?

Like that.

Joanne, Caroline and Vicki

The second group is made up of Joanne, Caroline and Vicki, who are considering the hurdles in this first episode. During their first episode they had sought help on the use of the software, from one of the student teachers who was assisting with the group. The student was relatively inexperienced and the intervention was not very constructive, with the result that although they achieved positive feedback from the system they did not appear to be fully proficient in the control of the software.

Group 4:Joanne, Caroline and Vicki
Episode 2: Hurdles (1.34.40)

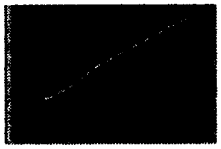
1	V:	What should we do?	
2	J:	Do ... hurdles.	
3	C:	Full screen. We can watch it first.	
4	C:	Right go back to the small screen. Let's have a look at the choices.	
5	J:	It's not that one.	Referring to graph 1.
6	J:	It's that one. It's that one.	Referring to graph 2. 
7	C:	Is it distance against time?	
8	J:	Yeh. Just check that.	
9	V:	Speed against time.	
10	J:	Speed.	
11	C:	Speed.	
12	C:	Just try to plot it with distance.	Very uncertain about how to change the axes - consult the Help Cards
13	J:	What are we doing? Just trying? Just trying?	
14	J:	Test.	
15	V:	Should I go on full screen?	
16	C:	Yeh if you like.	
17	J:	You can't have that ... we haven't got the graph on now.	

Figure 4

Vicki, who is in control of the mouse, initiates this episode by asking "What should we do?". In fact Vicki was in control of the mouse during the whole of the time that this group was working at the system. Joanne suggests "Hurdles" at line 2 and Caroline's suggestion, to play it in full screen first, forms an acceptance at line 3. After watching the video, Caroline suggests that they have a look at the choices, at line 4. At line 5, Joanne asserts that "It's not that one" and subsequently, at line 6, that "It's that one. It's that one". However the nature of "it" has not been discussed or previously agreed by the group Le. the JPS has not been established nor has any discussion towards its establishment taken place. Caroline begins to try to clarify the nature of the problem at line 7, with her question "Is it distance against time?". Evidently Joanne thinks that it is, from her response at line 8. However, Vicki takes her turn to point out that it is speed against time. Both Joanne and Caroline repeat "Speed" at the same time and seem perplexed. Caroline seems to suggest changing the axes to distance against time, at line 12. However none of the group appears to know how to change the axes. Joanne seems disheartened and confused at line 13, when she asks "What are we doing? Just trying? Just trying?". She seems to answer herself at line 14 with "Test".

Given the failure to establish a JPS and also to fully control the software, it would appear that Joanne is ready to settle for just getting to the correct solution. Vicki's question at line 15 relates to a technical option with the software, rather than being concerned with the problem itself, which in fact is typical of the nature of most of her limited interaction. Caroline's response of "Yeh if you like", implies acceptance but seems to suggest that it is of minor significance. Joanne, however, protests at line 17 that "You can't have that ... we haven"t got the graph on now". In fact the graph was being overlayed on to the full screen motion, but none of the group seemed to be aware of this. It was also the case that the axes were set to height against time and, by chance, they had matched up the correct graph although they seemed to remain unaware of this.

No discussion about the problem had taken place and there had been no progress in establishing, or even agreeing on the focus for, a JPS. A superficial observation of this group would have suggested that the group was successfully interacting with each other and with the system, and also that they were receiving positive feedback. However this close analysis does illuminate how misleading this impression would in fact be.

Summary

A particular feature which soon emerged from the analysis was the pattern of Chantel's utterances. Chantel is instrumental in giving a lead to the collaboration throughout the episode concerning the cheetah, by the way in which she combines her assertions with a question inviting acceptance or repair. Over the course of this episode Chantel asks most of the questions which are posed, of which five are of the form "wasn't he" / "won't he" etc and are linked to a preceding statement. In using this technique, Chantel not only gives a lead to the interaction in the group but also facilitates the responses of the others, with her invitation for acceptance or repair. In this respect Chantel's role is resonant with Vygotsky's notion of "a more capable

peer" in relation to the zone of proximal development - the distance between the actual development level as determined by independent problem solving and the level of potential problem solving under adult guidance or in collaboration with more capable peers.

The work of this group also provides several examples of the use of language combined with gesture in response to what is being observed on the computer screen. These examples support the claims for the role of the computer in supporting collaborative learning, made by Teasley and Rochelle. They argue that participants in collaborative activity are not wholly dependent on language to maintain shared understanding. They see a major role for the computer in supporting collaborative learning by providing a context for the production of action and gesture, which can serve both as presentations and acceptances. Thus the simultaneous production of matching language and action by separate partners can provide opportunities for acceptances of new ideas and also for repairs. There is further resonance with the arguments of Jones and Mercer (1993) in relation to the the role of the computer in the learning process. They argue that a communicative approach might place less emphasis on the relationship an individual learner has with the computer and more on the computer as a medium for the facilitation of communication. This argument is put, mainly from the point of view of the teacher and pupil relationship by Jones and Mercer. However the results of this study also highlight the significance of such a role for the computer/multimedia system in acting as a medium for communication between peers.

In most of the episodes involving the second group, no discussion about the problem took place and there was no progress in establishing, or even agreeing on the focus for, a JPS. A superficial observation of this group would have suggested that the group was successfully interacting with each other and with the system, and also that they were receiving positive feedback. However this close analysis does illuminate how misleading this impression would in fact be. This finding supports the observations made by Atkins and Blissett (1989) in their study of the role of pupil discussion, which they note varied from a trivial and superficial conversation about the problem to real engagement with its constraints and possibilities. They argue that, although discussion takes place, and that this looks like evidence of interaction it does not of itself guarantee effective learning. This also highlights the importance of the teacher in monitoring the quality of the process.

A further aspect of much of the discussion was the fact that it merely centred on defining the focus of the task and then on simply deciding which graph fitted, by a mixture of luck and guesswork, reflecting the dangers predicted by Hughes (1994) of a concern with the solution rather than the problem. There was no evidence of individual sketching of graphs or of any prior reflection. This was one of the central aims of the design of the multimedia-based activity, which was consistent with one of the preliminary findings of the NCET evaluation, as reported by Hughes, of the need for reflective moments and also with the need for reflection on the mathematical features of the problem itself, as argued by Hoyles and Noss (1992).

Another distinct difference between the groups was the way in which a "more capable peer" failed to emerge in the second case. Caroline seemed to show the potential on a number of occasions, when she sought to clarify the task itself and also

when she made her suggestion about sketching the graphs. However the force of Joanne's personality seemed to dominate the working of the group and from the start, when there was some evidence of her becoming disheartened and confused, Joanne seemed to be more concerned with the solution rather than the problem. A further particular feature of the interaction in this group was the minimal level of involvement of Vicki and also the fact that she was in control of the mouse throughout. Subsequent classroom observation and discussion with the class teacher suggested that Vicki was generally not well motivated and participated at a minimal level, if at all.

Conclusions

One conclusion that can be drawn from this study is that the use of collaborative group work with multimedia has the potential for generating high levels of pupil motivation and collaboration. However the aim of this study has been the investigation of the potential of collaborative learning using multimedia, rather than simply collaboration. It is clear that collaboration and by implication, discussion and interaction, are pre-requisites for such learning to take place. However, this in itself is no guarantee that collaborative learning will occur as highlighted by Atkins and Blissett. This concern for the quality of the interaction represented a shift of attention from classroom collaboration at the start of the study towards classroom interaction later.

Teasley and Rochelle (1993) adopted an alternative approach by defining collaboration at the start of the process from their theoretical perspective, based upon an assumption of the type of behaviour which is expected to lead to effective learning. Thus they define collaboration as "a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" and this leads on to the notion of the Joint Problem Space (JPS). As indicated earlier this perspective owes much to the work of Vygotsky.

Forman and Cazden (1985) observe that when they sought to explore Vygotskian perspectives for education, they immediately confronted questions about the role of the student peer group. In this study the process began by exploring the role of the peer group and led to the perspective representing the starting point of Forman and Cazden's enquiry. Forman and Cazden point towards Vygotsky's notion of internalisation, by which the means of social interaction, especially speech, are taken over by the child and intemalised. Development proceeds when interpsychological regulation is transformed into intrapsychological regulation. They further highlight the importance of Vygotsky's notion of the zone of proximal development and his hypothesis that children would be able to solve problems with assistance from an adult or more capable peer before they could solve them alone. They also point out that it appears that a similar process to the interpsychological-intrapsychological regulation may also occur in collaborative contexts where neither partner can be seen as "more capable", but where partners may assume separate but complementary roles.

As this study developed, this perspective in the tradition of Vygotsky came to assume increasing relevance and importance. The overall approach to the use of the

multimedia system could be seen to be consistent with such a view and the research methodology adopted in relation to the focus of the study was significantly influenced by such a tradition (Mercer 1991; Teasley and Rochelle 1993). The resulting framework illuminated the pupil-pupil interaction in particular and the perspective as a whole highlighted the crucial role of the teacher in this process.

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