Integrating Pedagogy and Software Design to Support Discussion in the Primary Curriculum

Rupert Wegerif[1], Neil Mercer[1], and Lyn Dawes[2]

Draft of:

Wegerif, R., Mercer, N. and L. Dawes (1998) Software Design to Support Discussion in the Primary Classroom. *Journal of Computer Assisted Learning.* 14 (3): 199-211. ISSN 0266-4909

Abstract

This paper puts forward a framework for the integration of pedagogy and software design to support educationally valuable discussion within the primary curriculum. In order to illustrate and to evaluate this framework two educational programs were designed to be used in conjunction with a series of lessons to coach the use of 'exploratory talk' in small group work. Evaluation of the first item of software, in the area of citizenship, focused upon the difference that off-computer lessons in exploratory talk made to the way it was used. Evaluation of the second program, in the area of science, focused on the effect of the overall approach on learning outcomes. The results of these two illustrative studies support the value of the proposed framework. The first shows that combining software design with the off-computer coaching of exploratory talk can enhance the quality of interactions at the computer. The second shows that, with this pedagogical framework, computers can be used to stimulate collaborative learning and to direct it towards curriculum goals.

Key Words

Citizenship, Collaborative Learning, Discourse Analysis, Evaluation, Friction, Primary Education, Science

Introduction

In Britain, as in many other countries, computers in primary schools are mainly used by more than one child at a time. This appears to be an efficient use of a relatively scarce resource. Teachers, when asked, also justify the use of group work at computers as a support for peer learning and the development of communication

---

[1]Centre for Language and Communications, School of Education, The Open University, Walton Hall, Milton Keynes, MK7 6AA. Email: R.B.Wegerif@open.ac.uk. or N.M.Mercer@open.ac.uk.
[2] School of Education, de Montfort University, Polehill Campus, Bedford.

skills (Crook, 1994). A number of studies have reported on the potential of computers to support educationally valuable small group work (Howe, Tolmie, and Mackenzie, 1996; Hoyles, Healy, and Pozzi, 1994; Light, 1993; Light, Littleton, Messer and Joiner, 1994). However the Spoken Language and New Technology (SLANT) project, which looked at children's interactions around stand-alone computers in ordinary classrooms, found that children's talk together around computers is often of limited educational value (Mercer, 1994; Wegerif and Scrimshaw, 1997).

The research reported in this paper responds to the findings of the SLANT project through developing and evaluating a framework for the design and use of software to improve the quality of interaction around computers in the classroom. The proposed pedagogical framework combines a programme of lessons to coach the use of 'exploratory talk' in small group work with the design of software to support 'exploratory talk' in a way which is directed towards goals within the primary curriculum. To illustrate the cross-curricular potential of this approach two items of software were designed to relate directly with two different areas of the curriculum, Citizenship and Science.

Exploratory talk

The SLANT project, referred to above, analysed over fifty hours of children's talk around computers. As well as finding that the quality of talk was often not all that the teachers hoped, the project team developed a way of understanding the cognitive dimension of children's talk around computers. This was characterised using three 'types of talk', which Mercer, (1995, p 104) described as 'social modes of thinking'. A full account of these types of talk, supported by illustrative transcripts, was given by Mercer (1995) and a version of this can be found in Wegerif and Mercer (1996). Here, for reasons of space, the three types of talk are described more briefly. Abstracting greatly from Mercer's account, these three types are:

- **cumulative talk**: 'in which speakers build positively but uncritically on what the other has said';
- **disputational talk**: 'characterised by disagreement and individualised decision making';
- **exploratory talk**: 'in which partners engage critically but constructively with each other's ideas'.

In the most recent account of these types of talk, Wegerif and Mercer (1997) apply Habermas's theory of Communicative Action (1991,) to argue that these 'social modes of thinking' describe fundamental orientations that participants in dialogue can take towards each other. They are not meant as a coding scheme but as a way of understanding the dynamics of social thinking. Exploratory talk, on this interpretation, is a particular version of what Habermas calls 'communicative rationality'. This is rationality defined not through rules of logical inference but through orientations and social ground-rules supporting a free and open encounter between ideas.

While it was influenced by conceptual analysis, our characterisation of exploratory talk was also influenced by direct empirical research and by the findings of research on effective collaborative learning reported in the literature (summarised in Wegerif and Mercer, 1996), particularly the work of Kruger (1993) and Light, Littleton, Messer and Joiner (1994).

Out of this combination of sources the following pragmatic ground rules for exploratory talk are provisionally proposed:

1 all relevant information is shared
2 the group seeks to reach agreement
3 the group takes responsibility for decisions
4 reasons are expected
5 challenges are accepted
6 alternatives are discussed before a decision is taken
7 all in the group are encouraged to speak by other group members

The first three rules in the list serve to bring the group together. These three rules are shared with cumulative talk. Ground rules four and five focus on the explicit reasoning which characterises exploratory talk as opposed to cumulative or disputational talk. In exploratory talk, challenges stimulate joint reasoning. They do not lead to a loss of co-operation and a switch into disputational talk. In disputational talk participants may still offer apparent arguments but are in fact focusing on 'winning' rather than on understanding or solving a problem together. Rule six reflects the findings of research on collaborative problem solving, particularly that of Kruger (1993) which has found that groups which do best are those which consider alternatives before deciding. In contradistinction to some researchers (e.g. Howe, 1992) we argue that this generation of alternative views does not necessarily imply different initial conceptions of the problem by the participants in collaboration but can itself be generated by the ground rules of the talk. The final rule was a product of empirical experience working with groups of children. We found that the abstract right to participate, as in Habermas's characterisation of the ideal speech situation (1991, p 87), was not sufficient. In practice, children often needed to be actively encouraged by their peers to speak and to put forward their views. These ground rules again emphasise our focus on the generative power of the interaction, rather than on the prior dispositions and views of the participants.

Exploratory talk is a type of talk that actively generates alternative claims and supports the reasoned competition between these claims.

Teaching Exploratory Talk

The content of the off-computer programme which was developed to teach these rules is described in more detail by its main originator, Dawes (1995, 1997) and so will only be outlined briefly here. (A guide for teachers is being prepared.) The programme consists of a series of nine lessons. Each lesson is designed to last for about one hour and focuses on one or more of the ground rules to be coached. Early lessons focus on skills such as listening, sharing information and co-operating while later lessons encourage critical argument for and against different cases. The children are given opportunities to practise discussing alternative ideas, giving and asking for reasons and ensuring that all members of the group are invited to contribute.

The effectiveness of exploratory talk, and of our programme to coach exploratory talk, was evaluated in the study through video-taping groups working together on Raven's reasoning tests. Analysis shows both a clear relationship between applying the ground rules of exploratory talk in groups and solving the Raven's test problems (Wegerif, Mercer and Dawes, in preparation). It also shows that the pedagogy was effective in coaching the ground-rules of exploratory talk and so in enhancing group performance on Raven's tests. This confirmed the published findings of an earlier study (Wegerif, 1996).

Principles for software design

Fisher (1992) noted that the talk of pupils working together on tutorial software commonly had the same IRF (initiation, response, follow-up/feedback) discursive structure as most teacher-pupil dialogue. Wegerif (1995) proposed a further possibility, the I*D*RF (Initiation, *Discussion*, Response, Follow-up) exchange pattern, where an element of pupil to pupil talk is inserted into what would otherwise be a directive teaching exchange dominated by the computer interface. This is the kind of interaction around the computer we were aiming to promote by combining coaching in exploratory talk with the use of interfaces designed to prompt exploratory talk. For this alternative form of educational exchange to occur, there must be a switch in mode after the computer's 'initiation', putting active engagement with the software on hold while pupils jointly consider their next move. The interesting thing about this exchange structure, from a pedagogical point of view, is that it has the potential to combine interactive learning with directive teaching (so channelling peer group activity towards appropriate curriculum goals).

The effect of different software interfaces on the quality of children's talk was investigated using the transcripts and video data collected by the SLANT project. A computerised concordancer was used to trawl the transcript data for features indicating exploratory talk. Words such as 'because', 'so', 'if' and 'why' were hunted for. Where exploratory talk was found the videos were carefully studied to see what, if any, impact the software was having on supporting or inhibiting the talk. Group dynamics and the educational context were important in encouraging exploratory talk, but software factors also appeared relevant. (See Wegerif, 1997, for a fuller account of this research). The detailed examination of the videos revealed that the following interface design features were effective in supporting exploratory talk:

- putting evidence which could be used in reasoning about choices clearly on the screen where children could point to it
- presenting choices embedded in a motivating narrative
- making problems sufficiently complex to benefit from being analysed through reflection and discussion
- using a simple interface with multiple choice options rather than typed input
- avoiding any encouragement towards turn-taking, e.g. not using discrete serial problems.

Another source of relevant research on effective interfaces and task design comes from Howe and colleagues at Strathclyde University who have conducted a series of studies of children working in groups at science tasks both with and without computers(Howe *et al.*, 1992; Howe, Tolmie, and Mackenzie, in press; Tolmie *et al.*, 1993). They conclude that computers can be used to shape the direction of pupil dialogue (Tolmie *et al.*, 1993). Specifically in the area of the use of science simulations, they argue for the value of software that obliges pupils to make their predictions explicit, and to come to agreement.

Integration with the talking lessons

Both programs were designed to support and scaffold exploratory talk within specific areas of the curriculum. In the program 'Kate's Choice' the phrase 'Talk together about what Kate should do' (Figure 1) cues exploratory talk about the alternatives presented on the screen. Similar cues are provided in the Science software. This illustrates the way the interface was designed with the off-computer programme where the phrase 'talk together' had been used to cue exploratory discussion according to the agreed ground-rules. From the point of view of a programme of lessons to teach effective communication, the software had to facilitate a 'fade out' of the teacher's 'scaffolding' role, so that children would apply generic skills for joint reasoning and the construction of curriculum-related knowledge without teacher support.

The Citizenship software

Design

This software was designed to integrate with a government sponsored Citizenship Curriculum pack ('You, Me, Us' Newton and Rowe 1994). This is partly based upon the guidance of the National Curriculum Council on Citizenship and emphasises the importance of discussion and considering the perspective of others, especially victims, in reaching moral decisions.

The aim of the software is to encourage reflection about moral issues through stimulating exploratory talk about the conflict between personal morality (loyalty to a friend) and social morality (stealing is a crime). It leads children to consider different perspectives, particularly the perspective of the victim, before coming to a moral decision. In doing this it fitted the Citizenship curriculum and was designed to be used in conjunction with a section on 'Property and Law' in the curriculum pack.

All the design principles given above were applied. There were potentially complex problems embedded in a narrative structure; decisions taken by the group made a real difference to the outcome of the story. This was achieved by using a 'hyper-fiction' in which different choices led to different consequences for the characters. Arguments for use in discussion were displayed on the screen as in Figure 1. At a later point, when the children were asked to decide the fate of the boy who had stolen some chocolates, all the different opinions of the different characters in the story were made available through icons of their faces which could be clicked on. This supported the goals of the citizenship curriculum of taking the views of others into account in reaching moral decisions. Typing was kept to an absolute minimum.

Evaluation

This software design has been evaluated in two separate studies, the first using a black and white version made with HyperCard and the second a colour version made with MacroMedia Director. Evaluation focused on whether the use of the software, in combination with the intervention programme, led to improved interaction around the computer and the use of exploratory talk. The difference made to the quality of interaction around the software by the intervention programme was explored, in both studies, through the use of a control class who were given the software without being given the off-computer intervention programme. Groups of children were observed and videotaped using the software. These groups, a total of five target and three control groups, were selected by the teacher as representative of the class as a whole. The children concerned were all aged nine or ten, the schools were state middle schools and the groups were, as far as possible, mixed gender and mixed ability.

We were also interested in evaluating learning within the Citizenship curriculum. Classroom observation and qualitative evaluation of the video-recordings showed marked differences in the way that children who had been coached in 'exploratory talk' responded to the software in comparison with children from the control classes. Our qualitative analysis of the talk supported the view that children were meeting the curriculum aims, though we have no more precise outcome measures to support this claim. The talk of most of the target-class groups exhibited the following features:

- Asking each other task-focused questions.
- Giving reasons for statements and challenges.
- Considering more than one possible position.
- Drawing opinions from all in the group.
- Reaching agreement before acting.

By contrast most control groups observed moved forward through the story in one of the following ways:

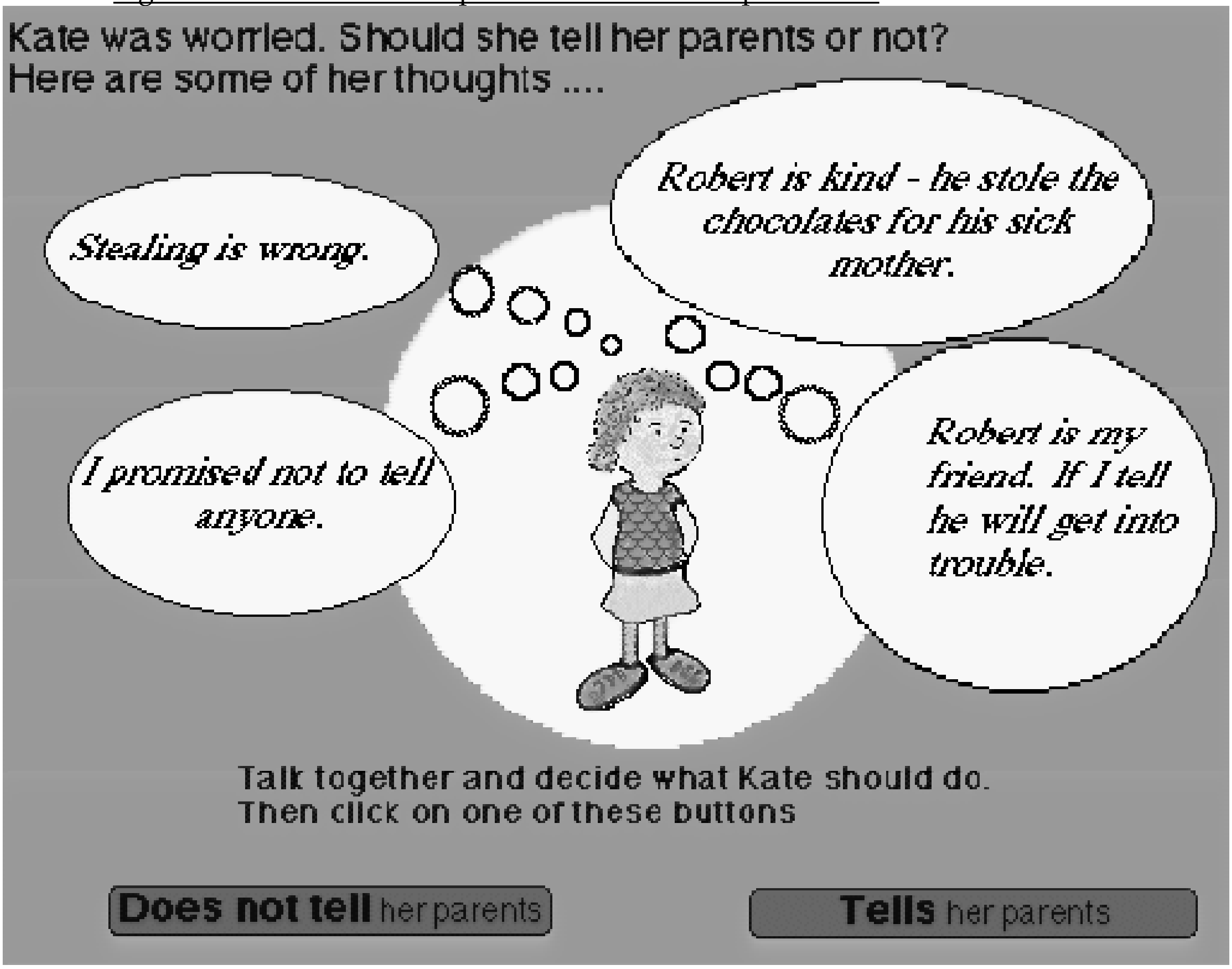
- Unilateral action by the child with the mouse.
- Accepting the choice of the most dominant child without discussion.
- Making an arbitrary, if joint, decision without debating the alternatives.

These features of the control group's style of interaction were those that the SLANT project had found to be common for children's joint use of computers. The more educationally desirable features of the interaction of children in the target class were all features which had been explicitly coached in the off-computer programme of lessons.

Transcript extracts

The two following extracts taken from this study illustrate the difference between the talk of the target and control class children around the computer. They are both taken from the first decision point encountered in the program (figure 1). Because the program was hypertext this was the only decision point which all the children were bound to take and so was used for systematic comparisons between the target and control conditions.

Figure 1: The first decision point in the Citizenship Software



Transcript 1 Post-intervention, target class children, Gary, Trish and Sue, on the first decision point of 'Kate's Choice'

Gary: Right we've got to talk about it.. (*T looks at S*)

Trish: What do you think? (*T points at G*)

Sue: What do you think?

Gary: I think even though he is her friend then um she shouldn't tell of him because em well she should tell of him em because was, was, if he's stealing it it's not worth having a friend that steals is it?

Trish: No

Sue: Why? I don't agree

Trish: We said why

I think that one as well do you? (*T points to the screen and looks at S*)

Gary: I think she should tell her parents Do you? (*G looks at S*)

Trish: I think I'm I think even though he is her friend because he's stealing she should still tell her parents and her parents might give her the money and she she might be able to go to the shop and give them the money

Sue: I think um ...

Gary: ... but then she's paying for the thing she stole so I think he should get the money anyway. He should have his ...

Sue: I think that he should go and tell his mother.

Gary: ... own money Mum

Trish: Even though she has promised

Sue: Because he's well you shouldn't break a promise really should you?

Gary: What's it worth having a friend if he's going to steal?

Trish: If he steals If you know he's stolen if she don't tell her parents then he will be getting away with it (*T looking at S*)

Gary: It's not worth having a friend that steals is it?

(*3 second pause*)

Sue: OK then (S puts hand on mouse)

Trish: Ain't worth it is it?

Sue: Tells her parents

Sue: (*clicks mouse*)

Gary: Yeh go on

(Total time on the screen: 109 seconds)

Commentary

Here the children ask each other for their views and demand reasons even for views which they agree with. They appear to consider alternatives carefully before taking a shared decision. The talk is therefore exploratory according to the ground rules given above. It is not perfect exploratory talk; few extra reasons are given in support of the initial position and it is hard to tell if Sue is persuaded by the reasoning or merely acquiesces to the strength of the majority view. While it is not perfect, it is a marked improvement, from an educational point of view, on the kind of talk recorded for this same group around different computer based activities before the training in exploratory talk. In the talk before the intervention Sue's challenges did not lead to reasoning but to 'disputational talk' in which both sides simply asserted opposing positions, with occasional insults, threats and fights over the control of the mouse.

Transcript 2 Jim, Tony, Susan, control class children, on the first decision point of Kate's Choice

Jim:	(*Reads from screen*) 'Talk together and decide what Kate should do then click on one of the buttons.'
Tony:	What should we do?
Jim:	Do that. (*Jim points at the screen*)
Tony:	(*Turning to call the teacher*) Excuse me. (*Turning back to group*) We don't know what to do.
Susan:	(*Clicks mouse*)
Jim:	Yes we do.

(*Total time on card 42 seconds*)

Commentary

Tony was baffled by the instruction 'talk together'. Susan, who happened to have the mouse, decided the choice for the group. Nobody objected to this assumption of control by Susan.

Quantitative evaluation

In all the transcripts and video-tapes it was found that the length of time spent at this decision point reflected the quality of the talk of the children. The two transcript extracts given above illustrate that the more the children gave reasons and considered alternatives the longer they took. It was therefore possible to use the automatic recording of the amount of time spent on the card, an evaluation feature built into the software, to compare the two experimental conditions. Of course the amount of time spent on the screen is only a rough measure of the amount of discussion. This measure does not, in itself, show that discussion was taking place, however evidence from classroom observation and from all the groups that were recorded strongly suggests that the amount of time spent on the card was a good indicator of the amount of discussion.

Table 1. Time in seconds spent on the first decision point of Kate's Choice

	Study 1 group times		Study 2 group times	
	Target class	Control class	Target class	Control class
	43	21	36	19
	63	35	47	23
	65	41	64	27
	67	48*	66*	31
	74	51	109*	42*
	82*	58		44
	97*	59		46
	102*	60		51
	105	62*		86
Means	77.55	48.33	64.4	40.9
S Ds	20.72	13.76	19.5	20.2

(* = video recorded group.)

Statistical analysis showed that the difference between the two conditions in Study 1 is highly significant ($p = 0.0015$. One-tailed T-test.) The results in the smaller sample of Study 2 were on the borderline of the 0.05 cut-off normally used for statistical significance in social sciences ($p = 0.056$. One-tailed T-test).

The Science software

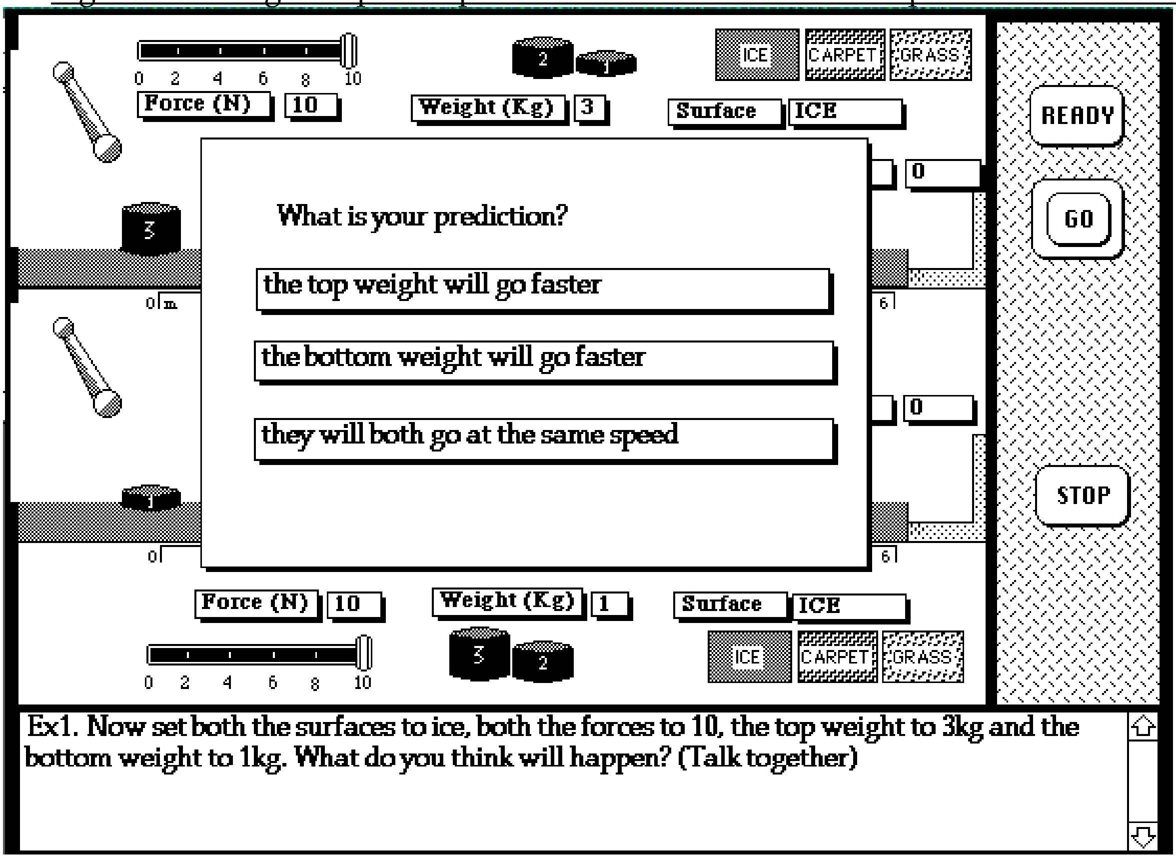
Design

The program was designed to teach statements of attainment from 'Experimental and Investigative Science' at Key Stage 2 in the National Curriculum relating to planning, predicting, observing and explaining experimental tests. Concurrently the program targeted 'physical forces', specifically knowledge about friction (DfEE, 1997).

The software combined an interactive simulation with a structured tutorial. Ten multiple choice questions about forces, friction and experimental methods ('fair tests') had to be completed before the simulation was reached and again afterwards. The simulation enabled users to explore the effects of initial force, surface texture and weight on the movement of objects (see Figure 1). Interaction with the simulation was directed with a series of prompts and dialogue boxes. These led the users through familiarisation with the controls to a series of experiments which began with very explicit instructions, moved through more general instructions to design experiences to test for different hypotheses and ended with the open-ended use of the simulation.

Design to support exploratory talk applied the work of Howe and colleagues referred to above (Howe *et al.*, 1992; Howe, Tolmie, and Mackenzie, 1996; Tolmie *et al.*, 1993). Each time the users sought to run the simulation they were prompted by the software to predict the result they expected (Figure 2) and after the run they were asked if their prediction was correct or not and why they thought that this was so. The general guidelines for design given above were adhered to. Evidence to support argumentation was provided on the screen in the form of the settings and the speed and distance readings. There was no typed input but simple choice buttons or multiple choice interfaces. While there was no explicit role-play and narrative the nature of interacting with a simulation provides a kind of role play and narrative structure in which decision taken have effects on later actions. As with the citizenship software, they were explicitly prompted to talk together to formulate predictions and explanations, and were encouraged to take joint responsibility for decisions.

Figure 2 Having set up an experiment the users are asked to predict the outcome



Evaluation

The evaluation of the Science software measured its effects on children's learning. Eight groups of nine and ten year old children (six groups of three and two pairs) carried out an activity based on the software. All the children had previously completed the off-computer training in exploratory talk. Each session lasted from 45 minutes to one hour, during which the talk of three groups was video-recorded. As described above the software itself incorporated pre and post tests which all the groups therefore completed. In addition short individual pre and post-tests were given to all the 22 children involved.

Transcript extract

Because the computer programme incorporated pre- and post-intervention questions into the simulation, we were able to focus in the learning of the children by looking at their talk around questions which they completed correctly in the post-test, having previously made errors in the pre-test. In most cases the difference, the 'learning' in other words, could be observed the talk of the children. A transcript account of talk elicited by one such post-test question follows.

Q3 On the computer screen

Rough surfaces cause
a) as much friction as a smooth surface?
b) more friction than a smooth surface?
c) less friction than a smooth surface?

Rachel:	Which one do you think it is?
Cindy:	Wah, wah, wah (*Reading fast*) friction, mmmm, surface, mmm.
Rachel:	What do you think?
Cindy:	'c'
Rachel:	I think 'b' (*Laughs*)
Cindy:	I don't. Look 'changes more surfaces than a smooth surface' (Misreading the screen)
Rachel:	Yeh I know, but if you rub
Cindy:	(*inaudible*)
Rachel:	yeh I know but - wait, wait - listen, if you rub two smooth surfaces together right, will it be slippery or stable? (*Rubs hands together*)
Cindy:	Stable - depends how tight you've got it.
Rachel:	Cindy listen! If you've got oil on your hands and you rub them together will they be slippery or not? (*Rubs hands together*)
Cindy:	Well you see (*She rubs her hands in a parody of Rachel but in a way that makes them miss each other*) 'cos they don't rub together they go ...
Rachel:	Cindy! (*in mock exasperated tone*) If you've got ...
Cindy:	Yeh, they will be slippery! (*laughs*)
Rachel:	Yeh, exactly. So if you've got two rough surfaces and you rub them together it will not be as slippery will it?

Cindy: No

Rachel: So that proves my point doesn't it?

Cindy: mmm

Rachel: Yes, do you agree? Good. (*She clicks on answer 'b'*)

Commentary

In the pre-intervention test neither girl had seen the connection between the texture of surfaces and friction. Here Rachel appears to know the answer and persuades Cindy. She does so with reasons and an analogy of the effect of adding oil to ones hands when rubbing them. In the pre-intervention test she did not make this connection. Rachel's response to an initial disagreement is to give reasons and attempt to persuade her partner. Although this appears rather one-sided Cindy is genuinely persuaded and in other interactions Cindy was the one persuading Rachel. In the talk of the girls together using the simulation the recognition that, the more slippery the surface the less friction there is, appears several times in response to prompts for explicit explanations by the computer.

Note that the interface here could not be simpler or more 'tutorial' in design; yet it produces talk of the appropriate kind. We can see the IDRF (Initiation, **Discussion**, Response, Feedback) structure of the talk, where instead of responding immediately to the computer prompt the children sit back from the computer and discuss their possible response amongst themselves. In this case the pedagogical framework has facilitated transforming a simple computer-user interaction into a complex learning experience.

Quantitative evaluation

Pre-intervention and post-intervention group test results for the eight groups show that four increased their score by 2 points out of ten while four did not increase at all. Statistical analysis of this small sample, does not show significance.

Individual pre- and post- test results for 20 students using a structured interview of four questions marked out of 4.5 produced a statistically significant increase. The mean pre-intervention test result was 3 (SD 1.076) and the mean post-intervention test result was 3.65 (SD 0.829). A one-tailed t-test gave $p = 0.018$.

We hypothesise that these marked individual learning gains, after a short session with the computer, were the outcome of discussion between the children such as that given in the transcript extract, where they make their ideas explicit and help each other to learn.

Conclusion

This paper has proposed, illustrated and evaluated a distinctive approach to the use of computers within the Primary curriculum. One key tenet of this approach is that the educational activity is not defined by the software alone but by the software in pedagogic context (Crook, 1994; Mercer, 1994). Our design framework incorporates pedagogic context in three ways. First, software content is integrated with a programme of off-computer lessons which give children the skills to work effectively together at the computer. Secondly, the interface is expressly designed to support collaborative learning. And third, the software is designed to relate directly to the specific demands of the school curriculum. This framework has been illustrated through the example of the design and use of software to integrate with the Citizenship curriculum and with the Science curriculum. The results of our evaluation show (a) that the quality of interaction around computers can be improved by off-computer coaching in exploratory talk and (b) that our approach to design is effective in stimulating talk which supports curriculum learning. The main focus of this paper is on the pedagogical framework for the use of computers in the primary classroom which these two studies exemplify. We argue that this framework is not limited to Citizenship and Science but could, in principle, be applied across the curriculum.

This paper has focused on presenting and justifying the pedagogical framework for using computers in classrooms developed and evaluated in the Talk Reasoning and Computers (TRAC) project. For reasons of space we have not been able to present all the evidence we have to support our claims. Other relevant findings are that coaching in exploratory talk leads to measurable increases in both group and individual scores on reasoning tests and that the intervention programme changed and improved the interaction of children using normal educational software not specially designed for the study. Papers and reports focusing on different aspects of the project are available on the project web-site at URL: http://soe.open.ac.uk/clac/trac/

Acknowledgement

The research reported in this paper was funded by ESRC grant R000221868: Investigating Reasoning, Talk and the Role of Computers in the Primary Classroom.

We also gratefully acknowledge the cooperation of the schools of Milton Keynes who have supported our work.

References

Crook, C. (1994). *Computers and the collaborative experience of learning*. London and New York: Routledge.

Dawes, L. (1995). Team Talk. *Junior Education, 19*(3), 26-27.

Dawes, L. 1997. Teaching Talk. In *Computers and Talk in the Primary Classroom*, edited by R. Wegerif and P. Scrimshaw. p 189 - 196. Clevedon: Multi-lingual Matters.

Department for Education and Employment (1997) National Curriculum for England and Wales (http://www.dfee.gov.uk/nc/)

Fisher, E. (1992) Characteristics of children's talk at the computer and its relationship to the computer software. *Language and Education* 7, 2, 187-215

Habermas, J. (1991) The Theory of Communicative Action. Vol 1. Cambridge: Polity Press

Howe, C., A. Tolmie, Anderson, A. and M. Mackenzie (1992). Conceptual Knowledge in Physics: the role of group interaction. Learning and Instruction, 2, 3, 161 - 183.

Howe, C., A. Tolmie, and M. Mackenzie. (1996). Computer support for the collaborative learning of Physics concepts. In *Computer-supported collaborative learning*, edited by C. O'Malley. Berlin: Springer-Verlag.

Hoyles, C., Healy, L. and Pozzi, S.. (1994) Groupwork with computers. *Journal of Computer Assisted Learning* 10, 202-215.

Kruger, A (1993) Peer collaboration: conflict, cooperation, or both? Social Development, 2, 3, 165 - 185.

Light, P. (1993) Collaborative learning with computers. In P. Scrimshaw (ed.)*Language, Classrooms and Computers*. London: Routledge.

Light, P., K. Littleton, D. Messer, and R. Joiner. (1994) Social and communicative processes in computer-based problem solving. *European Journal of Psychology of Education*., 9, 1, 311-24

Mercer, N. (1994) The quality of talk in children's joint activity at the computer. *Journal of Computer Assisted Learning* (10):24-32.

Mercer, N. (1995) *The Guided Construction of Knowledge: talk amongst teachers and learners*. Clevedon: Multilingual Matters.

Rowe, D., and Newton, J. (1994). *You, Me, Us: Citizenship materials for primary schools*. London: The Citizenship Foundation.

Tolmie, A., Howe, C., Mackenzie, M. and Greer, P. (1993) Task design as an influence on dialogue and learning. Social Development. 2, 3.

Wegerif, R. (1996) Collaborative learning and directive software. *Journal of Computer Assisted Learning* 12:22-32.

Wegerif, R. (1997). Factors Affecting the Quality of Children's Talk at Computers. In *Computers and Talk in the Primary Classroom,* edited by R. Wegerif and P. Scrimshaw. p 177 - 189 Clevedon: Multi-lingual Matters.

Wegerif, R., and Mercer, N. (1996). Computers and reasoning through talk in the classroom. *Language and Education, 10*(1), 47-65.

Wegerif, R., and L. Dawes. (1997). Computers and exploratory talk: an intervention study. In *Computers and Talk in the Primary Classroom,* edited by R. Wegerif and P. Scrimshaw. p 226- 239. Clevedon: Multi-lingual Matters.

Wegerif, R., and Mercer, N. (1997). Using computer-based text analysis to integrate quantitative and qualitative methods in the investigation of collaborative learning. *Language and Education, 11*(4).271 - 287

Wegerif, R., and Scrimshaw, P. (Eds.). (1997). *Computers and Talk in the Primary Classroom.* Clevedon: Multi-Lingual Matters.