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USING COMPUTERS TO HELP COACH EXPLORATORY TALK ACROSS THE CURRICULUM

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Abstract—This paper reports on the evaluation of an educational programme that coaches the practice of reasoning together through talk to a class of 9 year old children. The programme is based on a socio-cultural theory of intellectual development and on recent research on the educational role of group work around computers. Computer software specifically designed to support discussion between children and to direct this discussion towards knowledge construction in the curriculum was incorporated into the larger educational programme. Evaluation showed a marked improvement in group cognition, some of which transferred to individuals. It also showed that the specially designed software was effective in integrating reasoning through talk with curriculum learning. Copyright © 1996 Elsevier Science Ltd

INTRODUCTION

The idea that there are general thinking skills which can be taught across the curriculum has come under criticism from two sources. Many assessments of thinking skills programmes have concluded that transfer of skills from the context in which they are taught to other contexts is low and that what transfer there is depends upon the way language is used by teachers and students to make connections between contexts [1–3]. On the other hand the argument that cognition is always situated in cultural practices made by Brown *et al.* [4] and by researchers adopting a socio-cultural paradigm such as Rogoff and Crook [5, 6], appears to question the possibility of there being general thinking skills. This paper describes research that responds to such criticism by the development of a language-based approach to teaching general reasoning skills across the curriculum. Computer-supported co-operative learning plays an important part in this approach. Computer-based work is used in a larger educational programme to integrate the practice of reasoning together through talk coached by exercises off the computer into different curriculum subject areas.

BACKGROUND

The nature and significance of exploratory talk

A range of studies of collaborative work at computers suggest that the quality of students' interactions is crucial to the learning outcome. Blaye *et al.* [7] report that disagreement in itself is less important than the fact that it stimulates verbalization. Light *et al.* [8] conclude from a range of studies of pair work on computer-based problems that the style of interaction is more predictive of post-test gains than initial differences in perspective. Light *et al.* argue that having to use language to make plans explicit, to make decisions and to interpret feedback seems to facilitate problem solving and promote understanding.

A study reported by Kruger [9] sheds light on the kind of talk most effective for shared knowledge construction. Kruger recorded and coded the talk of pairs working on socio-moral problems. She found that the quality of the outcome was related to the quality of the dialogue, particularly the amount of "transactive reasoning" described as "criticisms, explanations, justifications, clarifications and elaborations of ideas". Kruger argues that it is neither conflict nor co-operation that is important in collaborative learning but a combination of the two in a form of interaction which encourages critical challenges within a co-operative search for the best solution.

On the basis of a naturalistic study of collaborative learning at computers in classrooms, Mercer [10, 11] came to roughly the same conclusion as Kruger and used the term "exploratory talk", for the educationally desirable type of talk that emerged from his research. Exploratory talk is a style of interaction which combines explicit reasoning through talk involving identifiable hypotheses, challenges and justifications, with a co-operative framework of ground-rules emphasizing the shared nature of the activity and the importance of the active participation of all involved.

The research briefly summarized above suggests that exploratory talk has value in promoting improved learning outcomes. Exploratory talk also has educational value in its own right. This has received official recognition in the National Curriculum for England and Wales [12] which has set objectives requiring children to be assessed on the quality of their spoken language, particularly their use of explanations and arguments.

Socio-cultural theory, "exploratory talk" and "thinking skills"

According to the socio-cultural paradigm, much influenced by the work of Vygotsky, intellectual development occurs through induction into cultural practices. In the literature on cognitive development viewed from a socio-cultural perspective there has been an emphasis on the teaching and learning of specific forms of cognition related to specific cultural practices [13, 14]. Socio-cultural perspectives have been seen by some as opposed to the idea of general "thinking skills". Crook [6], for example, writes that the idea of "thinking skills" carries with it connotations of discrete "mental processes that are deployed freely across problem-solving domains". Crook's criticism of some of the theory in the "thinking skills" tradition is a cogent one. However it is possible that at least a part of what is intended by the notion of general thinking skills can be usefully translated into the socio-cultural paradigm through the idea of "communicative rationality" [15]. The term "communicative rationality" is taken from the German philosopher Habermas who argues that rationality is not an abstract process but is always embodied in situations where shared understanding is constructed through language [16]. Habermas's attempts to specify the ground-rules of communicative rationality approach some of the ground-rules of the more practical classroom-based type of communication here being called "exploratory talk". The research described in this paper was based on the specific socio-cultural perspective that general intellectual development, including what is meant by learning general thinking skills [17], is linked to induction into the cultural practice of communicative rationality. This theoretical framework gives significance to the encouragement of exploratory talk in the classroom.

The apparent success of Mathew Lipman's "Philosophy for Children" method appears to support a socio-cultural perspective on intellectual development. Lipman's method coaches a version of exploratory talk in the classroom through philosophical debate and drawing children into what Lipman calls "a community of inquiry" [18]. However on a socio-cultural model the transfer of "skills" between sessions teaching general skills and other specific educational contexts cannot be assumed and indeed evidence for such transfer is limited [3]. The Oxfordshire Thinking Skills Programme sought to overcome the transfer problem by developing a common language for problem-solving skills across the curriculum and by teaching these skills in a manner embedded in each curriculum subject [1]. The programme described in this paper follows a similar strategy of relating talk to learning in specific curriculum subject areas through the use of computer-supported collaborative learning.

The role of computers in supporting exploratory talk

Barnes' early advocacy of the educational importance of talk of an "exploratory" kind [14–20] found official endorsement in the Bullock report [21], through the work of the National Oracy Project [22] and in the orders for the National Curriculum [23]. Nonetheless recent studies of primary classrooms indicate that children still have very little opportunity to engage in intellectual enquiry through talk, and are offered little guidance or instruction in the use of discussion by their teachers [24–26]. Reasons for this state of affairs are potentially diverse, and could include the difficulty teachers face in combining free and open discussions with their professional responsibility to teach a set curriculum, and teachers' assumption that the "ground rules" of educated discourse are self-evident to students [27]. However, computer-based collaborative activities can offer an alternative educational focus and framework for talk and research suggests that computers have significant potential for helping teachers support children's exploratory talk [6, 28]. Computers have very different role in classroom life from that of the teacher [29, 30], and even with directive "tutorial" software focused on curriculum topics, children can be seen to engage in uninhibited debate amongst themselves between the prompts and responses of a computer in a way that would not be possible with a directive teacher. Used as a support for communication the computer has the potential for integrating peer-learning through exploratory talk in which children apply educated discourse with the directed teaching of the curriculum [31]. This approach to the use of computers requires both the design of software to encourage discussion and the incorporation of the computers into a larger educational context supportive of exploratory talk [6, 32].

THE INTERVENTION PROGRAMME

An educational programme incorporating the use of computers was designed and implemented to explore and assess the proposed pedagogic framework. The educational programme consisted of a series of seven off-computer lessons followed by the use of two specially designed items of educational software. The computer-based work was intended to direct the generic exploratory talk taught in the off-computer lessons towards curriculum topics. One of the items of software was designed to support exploratory talk in the area of Science and the other to support exploratory talk in the area of Citizenship. The two very different areas of citizenship and science were chosen to illustrate an approach to using educational software which could, in principle, be applied across the curriculum.

The intervention programme was implemented in a class of 33 mixed-ability children aged 9 and 10 in an English state middle school. This implementation was evaluated using classroom observation, discourse analysis and pre- and post-intervention reasoning tests. A control class of 17 same age children in a neighbouring school were given the same pre- and post-intervention reasoning tests but were otherwise not involved in the programme. A further control class of same age children in the same school as the target class were used to compare use of the computer software between children coached in exploratory talk and those who had not been coached.

Off-computer exercises

The off-computer lessons took place once a week and each lasted an hour and a half. In each of the lessons the class worked both as a whole and in groups of three. These groups were established by the teacher to include mixed ability and mixed gender. The series of lessons began with exercises teaching sub-components of exploratory talk such as effective listening, giving information explicitly and co-operating as a group. For example in one of these lessons children used construction toys to build a model and then had to describe how to replicate this model to a partner who could not see it. The lessons moved on to exercises which encouraged critical argument for and against different cases. In one lesson called Dog's Home, for example, groups of children had to match pictures of six dogs with descriptions of five potential owners and decide which dog would have to be left out. In the third lesson period ground-rules for talking together were elicited from the children themselves in a whole-class discussion and then displayed prominently on the wall. Whole-class discussions then became a feature of the lesson periods with the class sitting in a circle and discussing themes of their own choosing. (More details of some of the lessons used can be found in Dawes [33].)

A key part of this coaching programme was raising awareness of the importance of their own talk amongst the children. This was done through looking at words used to describe talk and making a wall display of them, through showing video-tapes of the children's interactions to the class for guided discussion and reflection. The teacher-led whole-class discussion on the ground rules needed for talking together led to the following list which was displayed prominently on the wall of the classroom:

Ground rules for talk

(1) Everyone should have a chance to talk
(2) Everyone's ideas should be carefully considered

(3) Each member of the group should be asked:
—what do you think?
—why do you think that?
(4) Look and listen to the person talking
(5) After discussion, the group should agree on a group idea

The software

Two items of software were specifically designed and developed to support talk amongst groups of students and to direct it towards particular curriculum areas. (Design principles can be found in Wegerif [34].)

The base of the software developed to stimulate talk in the area of science was a simple simulation of plant growth, showing how this is affected by temperature and by the amount of light and water available. This basic design is similar to software simulations commercially available. To support exploratory talk two extra dimensions were added. First, the simulation was embedded in an overall narrative frame in which the children "role-played" scientists trying to find the formula to help a friend win the local flower-show. Second, what amounted to a "talk-support module" was added. This module interrupted the users as they tried to run the simulation by prompting them to talk to each other, asking them to make explicit predictions, relate these predictions to outcomes and explain why the predictions were either right or wrong.

The design of the "talk support" module was based on research done at Strathclyde University on computer-based collaborative learning in science [35–37]. This research indicates that significant learning gains follow if children are encouraged first to discuss predictions before conducting experiments and then relate the outcomes to those predictions.

Computer software was designed to integrate with the area of "citizenship" as an extra activity after whole-class discussion about the issue of stealing from shops. The software takes the form of a branching narrative about a girl called Kate divided between loyalty to her friend and pressure to tell others about his theft. The users have to make decisions as to what Kate should do or say at key junctures in the story, and these decisions determine how the story continues. The aim is not to direct the children towards a particular conclusion but to encourage genuine and wide-ranging debate about the issues. The theory behind this is that the capacity to "de-centre" sufficiently to take the point of view of others into account is the core component of moral development [38].

RESULTS

Qualitative discourse analysis of children talking at the computer

The effectiveness of the programme as a whole in integrating exploratory talk into curriculum areas was explored by comparing video-tapes of focal groups in the target class who had the coaching lessons with video-tapes of groups in a neighbouring class. Here is a comparison between a target class group and a control class group using the same software in the area of citizenship.

Target class. Natalie, Jane and George

(Natalie reads the instructions from the screen.)
Jane: Right we'll talk about it now.
Natalie: ssh (reads) "talk about what Kate should do. When you have decided click on one of the buttons".
Jane: Well what do you think?
George: Doesn't tell.
Jane: What do you think Natalie?
Natalie: Well I think she should tell because its wrong to steal—but its her friend.
Jane and George (together): Its her friend.
Natalie: Its her friend as well.
George: He knows its wrong.

Natalie: Yes but he's not doing it for her, er, for him, he's doing it for his mother. So I reckon she doesn't tell.
Jane: Yes, I agree.
George: Agreed, agreed.
Natalie: Doesn't tell then? One, two, three—(clicks).
George: Here we go, here we go.
Jane: (reads) "Have you all talked about it?"
All: Yes.
Natalie: (Clicks.)

Commentary. These children respond immediately to the cue on the screen which says "Talk together". They obviously know what this means and they sit back from the screen a little and turn to look at each other. Jane takes on a discussion facilitator's role asking the others what they think and encouraging a consensus. Through this everyone is involved. Reasons are given and questioned. Both Natalie and George give reasons against their original positions. Natalie appears to change her view. All children reach agreement before the mouse is clicked.

Control class. Mary, Cathy and Brian

(Cathy reads instructions from the screen)
Mary: Doesn't tell or tells? What should we do? Does she tell or doesn't she?
Cathy: We've got to guess.
Brian: Tells (in a loud and authoritative voice).
Mary: Tells (clicks).
Cathy: (Reads from screen) "Do you all agree?"
Brian: Yes (again in a loud and authoritative voice).
Cathy: Yes.

Commentary. The group does not know what to do despite the cue on the screen to "Talk about what Kate should do" and the teacher's prompt before they use the software suggesting that they should talk together. Cathy says "We've got to guess", implying perhaps that she thinks that there is a right answer and that they just have to guess which of the two it is. The one boy in the group decides for everyone with a single authoritative exclamation. No reason is given for his decision. No one questions it.

The differences between these two transcripts were typical of the differences between the target class groups and other groups of same-age children, both in the area of citizenship and that of science. The following features were exhibited in the talk of most of the target-class groups observed:

- 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.

These five features were all explicitly coached in the intervention programme as "ground-rules" for talking together. These features were found less or not at all in the talk of non-target groups. Most non-target 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 reasoning together about it.
- Drifting together to one or other choice without debating any alternatives.

The impact of the coaching lessons could also be seen in the response of the children to the simple cues put up on the screen to "talk about what Kate should do". The non-target groups were baffled and did not know how to proceed. The target groups clearly knew what to do.

Table 1. Key usage count for target and uncoached control groups

	Control	Target
Questions	4	13
Because/Cos'	0	7
If	0	2
Total words	496	942

Table 2. Key usage count for target and uncoached groups

	Uncoached control	Target
Questions	15	30
Because/Cos'	4	6
If	2	2
Total words	1211	1640

Quantitative discourse analysis of children talking at the computer

The qualitative analysis of episodes of talk was supported by quantitative comparison of the talk of two focal groups of children in the target class with two focal groups of children in the uncoached control class. This was based on a key usage count. A key usage is not simply a key word but a key word being used to serve a particular function. The use of a computer-based concordancer developed to facilitate discourse analysis [39] made it easy to extract the key word in the context of an utterance and to ascribe its immediate function. The following list of key usages were found to be indicative of exploratory talk:

if used to link a reason to an assertion;
because/cos used to link a reason to an assertion;
Any question used to support debate, including challenging 'why' questions, and more socially inclusive 'what do you think?' and 'do you agree?' questions.

Applying this "key usage" analysis to the full transcripts of two target (coached) groups and two control (uncoached) groups working on the citizenship software produces the results shown in Table 1.

The qualitative comparison of the talk of the children in the control and the target class working together at the Science software produced a similar result to the comparison of their talk at the Citizenship software. Sessions with the Science software were of variable length, some lasting over an hour. The first 20 minutes of the sessions of two target groups and two control groups were transcribed and compared. The results are shown in Table 2.

Pre- and post-intervention reasoning test results

The sixty problems in Raven's standard progressive matrices were converted into two similar tests so that the target and control classes could be tested in two modes: working as individuals and working in groups. These tests are described by their originators as tests of "clear thinking" and of "educive ability" which is an aspect of problem solving.

One of the tests was given to both the target class and a control class, divided up into groups of three, at the beginning of the intervention programme and again at the end. There was one question sheet and answer sheet per group and children were encouraged to talk together in reaching a joint solution. The other test was given to both the target and the control class but this time working as individuals. The individual tests were done at the beginning of the intervention period, 2 days after the group tests had been conducted, and again at the end, 2 days after the group tests.

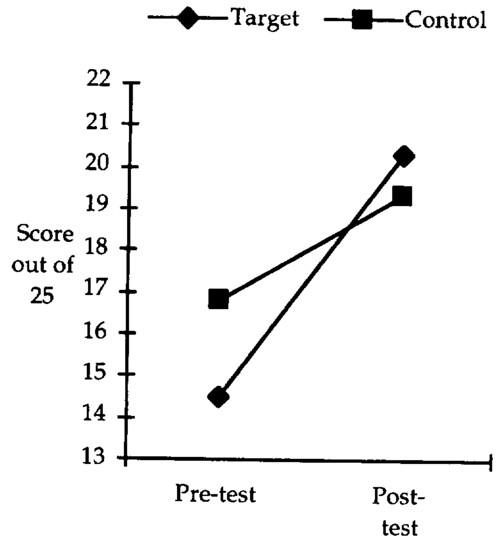

Fig. 1. Comparing target and control class means form the group reasoning tests.

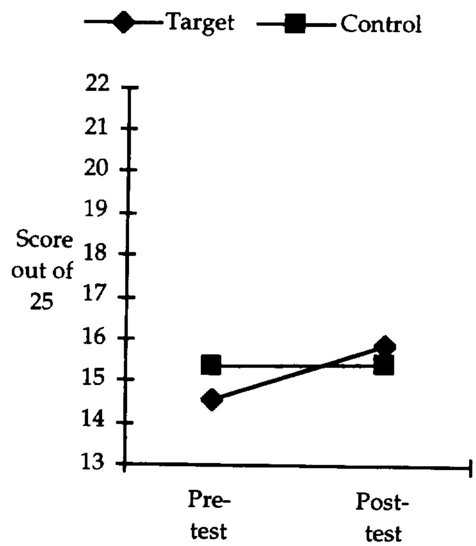

Fig. 2. Comparing target and control class means from the individual reasoning tests.

All the group scores in both target and control classes increased over the period of the intervention programme. The target class group scores increased by 32% while the control class group scores increased by 15%. The differences between the pre- and post-intervention test scores for all groups in the target class were compared to the differences between the pre- and post-intervention-test scores for all groups in the control class and it was found that this difference was significant ($Z = -1.87$, $P = 0.031$, one-tailed Mann–Whitney test, corrected for ties).

The mean individual test score in the control class remained approximately the same over the 8 week period. The mean individual test score in the target class increased by approx. 10%. A statisical comparison of the differences between the pre- to post-intervention scores of the target class individuals and the differences between the pre- to post-intervention scores of the control class individuals indicated that this result was significant ($Z = -1.65$, $P = 0.05$, one-tailed Mann–Whitney test) (see Figs 1 and 2).

Transcript evidence

The test results suggest that group effectiveness in problem solving has increased as a result of the coaching of exploratory talk. However to demonstrate this connection it is necessary to look at the change in quality of the interactions of the groups. Videotapes of focal groups were taken at both in the initial pre-intervention reasoning test and at the test after the intervention programme. From these it was possible to isolate the talk of the groups as they solved problems the second time that they had failed to solve the first time. The following two transcripts give an illustration of this type of analysis.

Natalie, Jane and George.

Pre-test talk on problem El
J: E1.
G: We've only got three more to do.
J: I know what it is.
N: That, that (rings number 3, a wrong answer, on the answer sheet). (sound of page turning)
Post-test talk on problem El
N: E1.
(pause)
N: Right I know. Wait a minute—look, that and that and that and that and that and that together—put it all together and what do you get you get that.
G: Yeh, cos' they've all got a dot in the middle.
N: Wait a minute.
J: I actually think its . . . .
N: I think its number 6.
G: Or number 7?
N: Who agrees with me?
G: No its number 7 cos' that and that makes that. Number 7 yeh.
N: Yeh.
J: Number 7. El (rings number 7, the right answer, on the answer sheet).

Commentary. In the post-test the group articulated what they were doing much more than in the pre-test. They took longer over each problem and produced more utterances. In the pre-test George was largely ignored by the two girls. He could be heard on the recording complaining about this. After the coaching programme the focal group asked many more questions, 33 compared to 8. Many of these were in the form: "What do you think George?" The effect of this was to draw George into the decision making process. On his own in the individual test George scored slightly less than either of the two girls, but here we can see his contribution moves the group forward. This illustrates the close relationship between the 'social' and the 'cognitive' aspects of group performance. All the children give reasons for their claims. On the video the two girls can be seen pausing to think about George's suggestion, which he backed up with arguments, before agreeing with it. This illustrates how, in the post condition, all are involved in thinking about each answer and agreeing to it before the group moves on. This was not the case in the pre condition where some children took a back seat while others took charge and decided what the answers should be on their own.

It was generally found to be the case that the problems which had not been solved in the pre-test and were then solved in the post-test, leading to the marked increase in group scores, were solved as a result of group interaction strategies associated with exploratory talk and coached in the intervention programme.

Quantitative comparison of children's pre- to post-intervention talk on the group reasoning test

The "key usage" quantitative method described above was applied to full transcripts of the pre- and post-intervention talk of three focal groups of children working on the group reasoning test. The results of the analysis of the children's language use over the period of the intervention programme, given in Table 3, show a marked shift in in the direction of using more questions and words found to be indicative of exploratory talk.

Table 3. Key usage count for the pre- and post-intervention tests of three focal groups

	Pre-test				Post-test			
	Gp1	Gp2	Gp3	Total	Gp1	Gp2	Gp3	Total
Test score	15	18	19	52	23	22	22	67
Questions	2	8	7	17	9	33	44	86
Because/'Cos	13	18	9	40	23	34	40	97
If	1	1	0	2	13	8	14	35
Total words	1460	1309	715	3484	2166	1575	2120	5761

CONCLUSION

The research described in this paper indicates:

- That coaching exploratory talk leads to improved group problem solving.
- That coaching exploratory talk appears to improve the scores of some individuals on reasoning tests.
- That computers can be used effectively to support exploratory talk amongst groups of children and to direct this towards curriculum ends

These results support the socio-cultural view that intellectual development results from being drawn into cultural practices and communities of practice. This suggests that to educate children to think for themselves we should first teach them to think with others. Being able to reason together with others in order to solve problems and build knowledge is a core practice in most areas of our collective life. This paper puts forward one way in which new technology could be used to help with the coaching and support of this core practice.

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