The role of educational software as a support for teaching and learning conversations

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Abstract: Much recent educational research focuses on teaching and learning within classroom conversations. This raises the question of the role of ICT as a support for such conversations. The central argument of this paper is that the dual nature of computers, as machines (objects) which can be made to act as if they were people (subjects), allows them to play a potentially distinctive and valuable role within educational conversations. This role is to resource and, at the same time, to frame and direct, learning conversations amongst small groups of children. Evidence in support of this argument is provided through the findings of an empirical study. In the study preparation for group work at computers was combined with the use of principles for the selection and design of software in order to develop educational activities to support discussion within the science and maths curricula over one year. 119 children aged between nine and ten participated in the study. The evaluation included video-recording, transcript analysis and a matching control group who covered the same areas of the curriculum without the intervention. The qualitative findings show learning occurring in the talk of the children working around computers and the quantitative findings suggest that this approach can produce significant learning gains within the normal curriculum.

Key words: cooperative/collaborative learning; elementary education; human-computer interface; improving classroom teaching; simulations

Introduction

Much recent educational research has emphasised the importance of conversations in the classroom (Mercer, 1995; 2000: Wells, 1999: Alexander, 2000). This naturally raises the question of the role of ICT in supporting teaching and learning conversations. This paper will use the findings of a recent research project to offer one possible answer to this question. But first the argument will be made that the ambivalent ‘ontological’ nature of computers as objects that can be made to interact as if they were subjects, can be exploited to provide a distinctive educational role.

The ambivalent ontological status of computers

‘Ontological’ is a term from philosophy referring to the ultimate nature of being. Understanding the ontological status of computers helps to understand the distinctive way in which they enter into conversations. Everyday language distinguishes between two main categories of being: subjects and objects. Subjects are assumed to have agency and moral responsibility. We normally explain what they say or do in terms of psychological attributes such as thoughts, feelings and beliefs. So, for example, when someone we meet says: ‘Hello, how are you?’ we know that they expect a response and that they may be offended if we do not respond. Objects, on the other hand, have no agency or responsibility. We normally assume that there are causal explanations for their behaviour. So, for example, if we pick up a child’s soft toy and it says ‘Hello, how are you?’ we will probably assume that a pressure switch was triggered and that caused a short pre-recorded message to play. In this case we are unlikely to feel any obligation to respond. If we were to respond it would be in the spirit of entering into a game.

Computers as partners in learning conversations have an ambivalent ontological status. They can be made to act like subjects in some respects and yet they are, in fact, objects. On the one hand educational software can be made to respond appropriately to inputs in such a way that users feel the need to explain their responses in psychological terms: it is common to say, for example that the computer, 'thinks' or 'makes mistakes'. On the other hand, even young children quickly learn that computers do not have the feelings, expectations and implicit judgements that human conversational partners invariably do have (Turkle, 1995).

In some contexts this difference between computers and humans can be of benefit. In some psychotherapeutic interactions, for example, the combination of a humanlike ability to ask questions with a machinelike patience and lack of judgement has been shown to be very effective (Suler, 2002: Rajendran and Mitchell, 2000: Jones, 1996). This paper will argue that the ontological ambivalence of computers also equips them, with the right educational software, to play a unique role in supporting teaching and learning dialogues.

The issue of control

In his influential book 'Mindstorms' Seymour Papert (1981) compared tutorial software, which he claimed was 'programming children', to his own vision of children 'programming computers'. This contrast between computers as agents controlling children or tools that children can control has been very influential. It is implicit in the widespread classification of computer software as either a 'tutor' or a 'tool' (O'Shea and Self, 1984: Crook, 1994). On one side the computer is conceptualised as a kind of subject, a 'tutor', and on the other side the computer is conceptualised as a kind of object, a 'tool'. A variation on the same theme is the classification of software on an 'open-closed' continuum according to the degrees of freedom offered to the user (see for example Fisher, 1992; Anderson et al. 1993; Newman et al., 1989).

The 'tutor-tool' distinction and the 'open-closed' continuum are referring to a marked difference that can be found in software designs. On one extreme lies the directive teaching software found in 'integrated learning systems' such as Research Machines' 'successmaker' and on the other extreme, software such as a word-processor that can be used in an infinite variety of ways. Most commentators, from Papert onwards, appear to give an evaluation to this distinction. More passive, open-ended software is seen as good for supporting meaningful learning (e.g. Preece and Squires, 1999). More directive, 'closed' and tutorial software is seen as limiting the possibilities of thought and discussion (e.g. Fisher, 1992). The assumptions underlying this literature are that it is bad to have computers controlling learners and good to get learners to control the computers.

It is possible that this opposition involves a misunderstanding that stems from a transfer of judgements about teacher-student interactions onto computer-student interactions. Tutorial software does not have the same effect on children as the equivalent style of interaction with a teacher. This is because children do not necessarily feel under the same social and psychological obligation towards machines that they sometimes might feel under when talking with teachers.

The difference between interacting with humans and interacting with computers emerges from studies of the use of computers by children with Autism and Asperger's syndrome (Rajendran and Mitchell, 2000). In this literature it is common to point out that these children enjoy interacting with computers because, whatever software they are running, computers are experienced as 'safe'. Computers are not experienced as having the expectations and judgements that make social interaction problematic for this group of children. A common theme of the literature is that, in interactions with computers, children with Autism can feel 'in control' in a way that they cannot feel when working with human beings (e.g. Huntiger and Rippey, 1997). This feeling of control is not related to a particular kind of software interface but is said to be generic to all interactions with computers.

IRF interfaces and I*D*RF exchanges

In 1975 applied linguists John Sinclair and Malcolm Coulthard studied talk in classrooms from the point of view of structures of language use. One of the patterns they isolated, the I R F exchange structure, has since become almost universally accepted as 'the essential teaching exchange' (Edwards and Westgate, 1994, p. 143). I R F stands for Initiation, usually a question by the teacher, Response, by a student, and Feedback by the teacher. For example a classic IRF could be:

Teacher: How many sides does a hexagon have?

Pupil: Six.

Teacher: Well done.

Recognising that the feedback move is not always explicit and that the teacher often uses the response of the pupil to cue a new activity or question, Gordon Wells replaces ‘Feedback’ with the more open term ‘Follow-up’ (1999).

This three-part exchange structure, sometimes also called the triadic structure (Lemke, 1990) has proved useful to researchers looking at talk between teachers and learners (Cazden, 1987: Mehan, 1979: Mercer, 1995). Many have noted that the IRF structure allows the teacher to keep control of the direction of the interaction with students. The student’s input is always framed by the teacher's prompts and evaluations. As a result the IRF exchange structure has been criticised by those that claim that it controls students too much and prevents them from thinking for themselves and asking their own questions (Young, 1991: Dillon, 1994: Wood, 1988). The IRF analysis has also been applied to interaction with tutorial software (Crook, 1994, p. 11-13: Fisher, 1992). In much tutorial software the computer asks a question, the user offers a response of some kind and the computer evaluates this response either explicitly or through the selection of the next screen or prompt. The criticism of the limiting effects of IRF in teacher student dialogue has been carried over to IRF type exchanges with computers.

However the ambivalent nature of computers, as seeming like a subject but actually being an object, equips them to support a different kind of exchange. This is most evident when two or more users sit down at a tutorial computer program. The computer program may take the initiative and pose a question directed towards some content area of knowledge to be covered (I), it may also insist on a response from a limited range of options (R) and finally, it may evaluate those responses either explicitly or implicitly through the choice of follow-up questions (F). This describes a common type of computer program designed to imitate an IRF educational exchange. However, when dealing with computers, a pair or groups of users have a new option. That option is to sit back from the computer screen and discuss their response together. This option is available because the computer is a machine and can therefore be put into the background and made to wait until a response is agreed upon in a way that would not normally be appropriate with a human conversational partner.

Discussion between the 'Initiation' and the 'Response' introduces a new kind of educational exchange which can be called I*D*RF to signify: Initiation, *Discussion*, Response, Follow-up (Wegerif, 1996). The educational value of this exchange structure is strengthened if, in the Discussion moment of the interaction, the computer switches from being a simulation of a teacher to becoming a more passive discovery learning resource or environment. In other words the I*D*RF learning exchange has the potential to integrate both aspects of the computer’s ambivalent nature.

The educational significance of I*D*RF

The suggested I*D*RF coding for some forms of computer supported discussion combines two very different kinds of interaction. The 'IRF' part refers to the user-computer interaction and the '*D*' to the spoken pupil-pupil discussion. Where the discussion between pupils is 'exploratory' talk (Mercer, 1995), with children thinking together and trying out alternative ideas, then I*D*RF also combines two very different educational genres. Taking the IRF sequence alone, users appear passive and the computer appears to be in control. This may be taken to correspond to what is sometimes, usually in a pejorative sense, called a transmission model of teaching and learning. In exploratory discussion mode, on the other hand, users actively consider their options using the information offered by the computer in the knowledge that the conclusions of the discussion will later be tested out upon the computer.

In this moment of the educational exchange the interaction the computer acquires the more passive role of a 'learning environment'. The '*D*' part of the I*D*RF exchange therefore corresponds to the kind of learning through discovery and the construction of meaning advocated by Papert and others. I*D*RF is interesting because it combines both these often contrasted modes of teaching and learning in one basic educational exchange.

In comparison with IRF interactions alone, on the one hand and peer discussion alone, on the other, I*D*RF has some clear educational advantages. Through the IRF framework the computer can stimulate and direct the talk of the children in order to meet the goals of a predefined curriculum. In the discussion moment children construct their own meanings. The I*D*RF exchange structure can therefore be seen as an ICT supported version of Vygotsky's Zone of Proximal Development (ZPD) – the zone in which teaching brings the spontaneously formed concepts of learners into relationship with the pre-existing concepts of a culture (Vygotsky, 1986). Vygotsky's model offers a third way beyond the transmission versus discovery dichotomy found in Papert's book *Mindstorms*. In the ZPD there is transmission but also the active construction of knowledge by learners. The I*D*RF structure can be seen as embodying a neo-Vygotskian model of teaching and learning: neither as transmission alone nor as construction alone but as both and as more. This third way is summed up in the phrase 'the guided construction of knowledge' (Mercer, 1995).

An empirical study of the I*D*RF exchange

A research team based at The Open University developed lesson plans and ICT activities for nine and ten year old children in three UK primary schools. This project had a particular focus on covering the mathematics and science curricula, however ICT-based activities in English and Citizenship were also included. There were 119 children in the experimental classes and 129 children in matching schools acted as controls, covering the same area of the science and maths curriculum but without our intervention. The details of the design and quantitative findings of this study, with particular reference to science education, are being published elsewhere (Mercer, Dawes, Wegerif and Sams, in press). This paper focuses on the support that the findings of this study provide for the hypothesis that stimulating I*D*RF educational exchanges around computers aides learning.

To encourage I*D*RF exchanges within this study the research team selected from existing software and designed new software according to principles that had been derived from earlier exploratory research (Wegerif, 1997). The team also worked with teachers to promote effective discussions through a series of 'talk lessons' (Dawes, Mercer and Wegerif, 2000A: Dawes, Mercer and Wegerif, 2000B). These lessons prepare the children for small group work around computers through teaching the ground rules of ‘exploratory talk’, talk in which questioning and reasoning is apparent. After this preparation ICT based lessons were given by the classroom teachers which included group work around software. To provide more qualitative data a representative group of three children was selected by the teacher in each class for video-recording when working with different items of software. The following two sections offer two examples of the I*D*RF educational exchange observed in these video-recordings, the first is taken from a science activity and the second from a citizenship activity.

1. Talking Bug

There are many 'open-ended' simulation programmes intended to teach science. Earlier observation studies suggested however, that while children enjoyed the interactivity of simulation programmes they often learnt little without a great deal of input from a teacher (Wegerif, 1997). The implication of these studies was that, rather than simply pressing buttons and getting responses, the children could have benefited from a stimulus to encourage them to think more about experimental design, predications and explanations for observed regularities. An initial programme tested this approach in the context of a simulation of friction. In this programme weights, surfaces and push forces could be varied to explore the effect of friction. Whenever the children attempted to run the simulation they were asked for a prediction and then, when the simulation had run, they were asked for an explanation of why their prediction was right or wrong. This simple approach to promoting discussion worked well (Wegerif, Mercer and Dawes, 1998). In the main study we decided to build a programme to work with existing simulations. We called this the 'talking bug' because its role was to 'bug' or bother students into talking together. It interacted with audio messages as well as text and looked like a ladybird so the name 'talking bug' was doubly appropriate.

When not active the Talking Bug is designed to sit quietly at a corner of the screen (Figure 1).

Figure 1. Talking Bug at rest

It can be minimised in this way at any time with a click of the mouse. When active (Figure 2) it sits on top of the current window. The Talking Bug was used in conjunction with simulations taken from Granada's widely used 'Science Explorer' programme. In the following transcript example (Transcript extract 1) the Bug prompted children to talk around a simulation of an experimental sound laboratory (Figure 3)

The recording was made of a group of three children, two girls and a boy, working around a computer in a computer room. The activity was part of a whole class lesson in which the teacher initially reminded children of previous work on sound, set up the science aims of the lesson and emphasised the importance of using the shared 'ground rules for talk' that had been established in earlier lessons (Mercer, Wegerif and Dawes, 1999).

Figure 2. Talking Bug Prompt

Figure 3. Science Explorer: the Sound Lab

Transcript Extract 1: Sound vibrations

Talking Bug: In this lab you can test how well four different materials block out sound. Which material do you predict will be the best at blocking out a high-pitched sound, like a whistle? Talk together to decide and say your reasons why before you click on a button.

Sandra: Um. Can you hear sound through wood? [Points to wood on list].

Brad: I think - What?

Sandra: Can you hear sound through wood?

Brad: I imagine you can, but I think that -

Kylie: How about glass? [Points to glass on list]

Brad: No – not glass, because of the vibrations. [He gestures to indicate vibrations]

Sandra: From cloth you can

Kylie: Yeah, but they haven't got cloth here.

Brad -vibrations- metal because it can't vibrate and and it's really strong.

Kylie: [To Sandra] It <u>is</u> strong isn't it. O.K. Metal. [Sandra nods].

Sandra: O.K. Here

Brad: What?

Sandra: If you hear sound with the metal -

Kylie: Well, you can't really 'cos if you like had metal walls, yeah, you wouldn't be able to hear anything around –brick wall-

Sandra: [Clicks mouse on the 'METAL' button]

Talking Bug: Thank you. Do you think this will be different for low-pitched sound?

The interface (Figure 2) is typical of a tutorial software and constrains an 'IRF' type interaction between the Talking Bug programme and the students. However this programme, in conjunction with their previous lessons establishing ground rules for talking together around computers, leads this group of children to discuss how materials block out sound and to make an explicit prediction based upon their shared experience. The IDRF structure is clear with the Talking Bug programme initiating (I), the children discussing (D) and then making a response (R - a mouse click by Sandra) with a final follow-up by the Talking Bug acknowledging their input and asking a new question.

The children predict that Metal will be the best material for blocking out high-pitched sound. Their reasoning includes the understanding that sound is transmitted by vibrations, however they mistakenly think that metal does not vibrate because it is 'strong'.

After prompting the children to make predications the Talking Bug guides them through designing an experiment to test their predications and then retreats to the top left hand corner of the screen (figure 1) leaving them to conduct the experiment in the virtual lab provided (figure 3). They learn that Cork is in fact the best insulator for high-pitched sound. The Talking Bug returns (it reminds them to click on it by twitching her wings) and asks them which material was best. When they select cork the Bug asks them to explain why their initial predication was wrong. As they struggle with this question the class teacher joins them and is able to build on the idea of vibrations offered by Brad and of the thickness of the material offered by Sandra to explain about the importance of compactness. The children appear to understand. Later, in the plenary, the teacher reinforces this point.

Taking the activity as a whole the prompts from the Talking Bug appear to stimulate these children to think about the problem together. Their initial conceptions give the teacher something to build on in offering a scientific explanation for their experimental findings.

In addition to this observational evidence there is some quantitative evidence that exchanges of this kind benefited measurable learning in the science curriculum. Both experimental and control classes were given a test of scientific understanding in the topics covered in year 5 of the UK curriculum, at the beginning and at the end of the school year. An ANCOVA (analysis of co-variance) revealed that the experimental classes significantly improved their scores in relation to the control classes (P=0.002; full details of the statistics are provided in Mercer, Dawes, Wegerif and Sams, in press). The questions we used were taken from optional SATs tests published by the UK government. The experimental classes had most of their science lessons over one year taught with the help of computer-based activities designed to produce I*D*RF exchanges. The statistical evidence therefore suggests that the kind of I*D*RF exchange reported above led to increases in measurable learning outcomes.

2. Kate's Choice

Our second example is taken from an interactive narrative designed by for citizenship called Kate's Choice. The story begins with two young friends, Kate and Robert, talking together. Robert has a box of chocolates and Kate asks where he got them. Robert asks her to promise to keep his secret before he tells her that he stole them. He explains further that they are a present for his mother who was in hospital. Kate then has to decide whether she should tell her parents of this or not. This is the first of a series of moral decisions that the children are asked to take after discussing the question together. The children whose talk is presented in transcript extract 2 below decided, after some discussion, that Kate tells her parents about her friend Robert’s stealing. In the story Kate’s mother then tells the shopkeeper, Mrs Cooke, who calls in the police. At this point the children are asked to reflect and consider if they made the right decision, looking at what the main characters in the drama think. Figure 4 presents this reflection screen with the opinion of Rob’s mother showing. As can be seen the apparent structure of the computer-user interaction is very directive and could be described as IRF. The computer initiates with a question: ‘Did Kate do the right thing?’ at the top of the screen and allows only two possible responses at the bottom. However the combination of teaching exploratory talk with this software design produced over 1500 words of serious discussion before the final decision was made. An illustrative extract from this long episode of talk is given below.

Figure 4. Did Kate do the right thing?

Transcript extract 2

[Computer text initiation: "Did Kate do the right thing? Click on these people to find out what they think. Do you agree with any of them? Do you disagree? Talk together and decide"].

Kath: [Clicks on Rob's mum and then reads the screen text shown in Figure 1]

"I don't think Kate did the right thing, Robert is a good boy. He only took the chocolates to be kind to me".

Alan: No I don't agree.

Kath: I don't agree with that –

Alan: That's just wrong.

Kath: Robert's Mum should be on Mrs. Cooke's side really.

Alan: Yeah. She should be more strict.

John: Next round. Kate's Mother. [Clicks on Kate's mum]

Alan: OK [reads from screen] "Kate did the right thing to tell. She should not lie to me or hide things from me. I am her Mother".

Kath: Alright John – you go first this time

John: I think that's alright actually, because if you don't tell her, and her mother finds out she's going to get really done because she ain't told her mum.

Kath: Yeah, then Kate's Mum will go round to Rob's Mum's house and say "You did this and you did that and your son is a bad influence to my daughter."

Alan: 'Cos he stole

Kath: But that's wrong as well. I know Kate <u>should</u> have told her Mum – and that's what she did, but if Kate didn't tell her Mum, then Rob's Mum would sort of fall out with Kate's Mum because I think Rob's Mum and Kate's Mum are friends so I think Kate's Mum is right. I agree with Kate's Mum.

Alan: Yes. I think about Kate's Mum – and it's also good for Kate, because she'll have a really guilty conscience and she'll feel really upset inside. And she'll-

Kath: And it will all start to bubble up inside her and she'll just have to tell somebody.

Alan: And Rob, I think if he doesn't get told now what's right and what's wrong, when he gets older he's going to get into a lot more trouble than just a box of chocolates.

Kath: Yes – in older life there's no second chances. He'd better start learning.

This talk fulfils the stated aim of the citizenship curriculum to encourage children to discuss moral issues together. Talking around the computer gives them a chance to take up a position in relation to a range of opinions and so to practice and develop their own moral voice. In this short extract they are seen to take moral responsibility for decisions using their own reasoning as a basis for criticising one adult's opinion while supporting that of another. Perhaps this is giving them the opportunity to appropriate and to practice voices that they have first heard elsewhere - for example the idea of a guilty conscience making someone 'upset inside' expressed by Alan or that 'in older life there are no second chances' expressed by Kath.

The I*D*RF role of the computer is clear. The screen prompts them with a question related to the aims of the curriculum and frames the whole discussion. The children eventually respond to the computer initiation by selecting the 'YES' button. The computer then leads them to apply the results of their discussion in order to choose and appropriate punishment for Robert. In this way the computer could be said to take an active tutorial role. But the computer also provides them with a range of opinions to explore. The activity around this computer screen illustrates how the more passive role of a computer, as a discovery environment for children who construct their own meanings, can be framed within a tutorial interaction in order to produce an effective learning conversation within a curriculum area.

Summary and discussion

The argument began with the claim that computers, considered as partners in dialogues, are essentially different from humans. This difference can be summed up as their ontological ambivalence – they are objects, machines, that can be programmed to act as if they were subjects, people. This means that the implicit claim in the literature that IRF interactions with computers have the same effect as IRF interactions with a human 'tutor' are not necessarily warranted. In practice students do not necessarily feel 'controlled' by computers in a way that they might feel controlled by a human tutor taking the same role and, as a result, simple IRF interactions with computers can support discussion, reflection and the active construction of meaning in a way that they may not normally do with human teachers. This claim is summed this up in the idea of an I*D*RF educational exchange around computers where the '*D*' stands for discussion between students. As an ideal type this combines, in a single exchange, curriculum focussed teaching with active learning by students. The evidence presented in this paper shows that a combination of pedagogy and software design can exploit the ambivalent nature of computers to make them serve as both interactive agents, or 'tutors', and as passive 'learning environments' within the one educational exchange.

The second half of the paper gave an account of how this theory had been applied in a recent study in primary schools which included two illustrations of I*D*RF exchanges in practice. The first illustration was of specially designed Talking Bug software, used in conjunction with Granada's Science Explorer. Here the computer took on two separate identities. As a simulated 'tutor', the Talking Bug, it asked the children for their prediction of the outcome of a certain experiment. They then turned to a computer-supported simulation of a laboratory to test out their predictions, before returning to the Talking Bug who evaluated their prediction and asked them to explain why they got it wrong. A similar duality of roles was found in the second illustration, an example of talk around Kate's Choice. The computer prompted the talk of the children and 'framed' it in a tutorial interaction while also offering them the opportunity to explore a range of opinions and test out the possible consequences of their ideas. In the Kate's Choice example these two roles were more integrated.

The main claim of this paper is that the ambivalent nature of computers appears to equip them uniquely well to support an I*D*RF educational exchange structure. This means that, with the right pedagogy and educational software, computers can not only serve as a shared focus for group work but they can also interactively direct that work towards the goals of the curriculum while also, simultaneously, serving as a learning environment in which students explore and test out their ideas. It seems likely that only computers can do all of this at once in an integrated way.

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