

# The Plausibility Problem: An initial analysis

Benedict du Boulay and Rosemary Luckin

School of Cognitive and Computing Sciences,  
University of Sussex,  
Brighton BN1 9QH.

`bend@cogs.susx.ac.uk` and `rosel@cogs.susx.ac.uk`

**Abstract.** Many interactive systems in everyday use carry out roles that are also performed — or have previously been performed — by human beings. Our expectations of how such systems will and, more importantly, should, behave is tempered both by our experience of how humans normally perform in those roles and by our experience and beliefs about what it is possible and reasonable for machines to do. So, an important factor underpinning the acceptability of such systems is the plausibility with which the role they are performing is viewed by their users.

We identify three kinds of potential plausibility issue, depending on whether (i) the system is seen by its users to be a machine acting in its own right, or (ii) the machine is seen to be a proxy, either acting on behalf of a human or providing a channel of communication to a human, or (iii) the status of the machine is unclear between the first two cases.

## 1 Introduction

Many interactive systems in everyday use carry out roles that are also performed — or have previously been performed — by human beings. Good examples of such systems can be found in computer-supported training. Here users perform some task and their performance is commented on by the system. However, as information and communication technologies are used in the lives of a greater number and variety of people, so the number of human-like roles these systems perform or mediate increases. The internet has brought new forms of interaction into people's homes, work and leisure environments. For example, One2One's 'Ask Yasmin' interactive customer service assistant can help people find out about mobile phone service options; the search engine 'Ask Jeeves' answers users questions in order to help them search for information on the world wide web and Amazon.com offers its users suggestions about the types of book they might like to read. Our expectations of how such systems will and, more importantly, should, behave is tempered both by our experience of how humans normally perform in those roles and by our experience and beliefs about what it is possible and reasonable for machines to do. So, an important factor underpinning the acceptability of such systems is the plausibility with which the role they are performing is viewed by their users. With respect to training systems, Lepper et al. [13] define the issue as follows:

“Even if the computer could accurately diagnose the student’s affective state and even if the computer could respond to that state (in combination with its diagnosis of the learner’s cognitive state) exactly as a human tutor would, there remains one final potential difficulty: the plausibility, or perhaps the acceptability, problem. The issue here is whether the same actions and the same statements that human tutors use will have the same effect if delivered instead by a computer, even a computer with a virtually human voice.” [13] (page 102)

The notion of plausibility is closely related to the notion of credibility [6]. Credibility is bound up with such concepts as believability, trustworthiness and expertise. Plausibility is more subtle and is concerned with effectiveness and acceptability within a role and relies on our sense of the differential social roles that humans and computers may be expected to play. So plausibility is one way of talking about a whole species of interactive system design issues where the designer is attempting to mobilise inter-subjectivity as a persuasive, seductive or supportive interactional device.

The design challenge raised by the plausibility problem is, first, to identify the situations in which the plausibility of a system becomes an “issue” for its users and, second, to establish whether and when it actually becomes a “problem” [5]. The debate surrounding Eliza and its more specific variants such as Parry, indicate that there are circumstances where users can suspend belief (as if watching a film or a play) and not be concerned over the status of their conversational partner as a machine. Eliza also reminds us that there may be circumstances where direct human-human interaction might be unwelcome and that any such inhibition may be usefully reduced by a machine acting as a conversational partner. Re-exploring people’s reactions to Eliza-like systems is extremely timely with the advent of virtual representatives being used to host web sites and offer advice (see for example <http://www.one2one.co.uk> and <http://www.axcess.com>). In some circumstances, implausibility might be counter-productive, causing users to distrust and then fail to make the best use of some system. On other occasions it may not be a problem at all: the provision of an ironic interchange that serves to amuse, perhaps even to motivate, for example.

Our research question is not whether individuals respond to systems in ways that are similar to their response to other humans. Nor is it simply whether giving such systems surface human-like characteristics (such as voice output or displaying an animated face) makes a difference. The central notion is, in training systems or in other areas such as information provision, healthcare, e-commerce or leisure systems, whether copying the tactics normally employed by humans playing roles in those areas (trainer, salesman, advice-giver for example) works when the role player is a machine. In some ways detecting implausibility is easier than detecting plausibility. For instance, one indication that a system is behaving implausibly might be when it evokes irritation in the person using it (e.g. through the jaunty friendliness that some systems adopt). Another reaction could be reduced engagement with the task in hand. We are certainly interested

in affective responses (such as irritation) that might accompany implausible machine exchanges. However, we are especially interested in what further effects on task performance might follow from this. Such effects could include failure to answer subsequent questions in the exchange, provision of partial or incorrect information, adopting a frivolous mode of response, becoming distracted, or simply abandoning the session that is underway. Reactions will vary according to the circumstances in which the system is being used. When using an e-commerce site users may well simply ‘vote with their feet’ and abandon the interaction, whereas users of training systems may well not have this latitude and so persist.

Our investigation of the factors which contribute to systems being regarded as plausible and those which undermine takes into account the system purpose and its characteristics. We may suppose that a dumb system playing a limited role, whose role is expected to be limited and which, in fact, acts in a limited way will be perfectly plausible, whilst a similar system that moves outside reasonable parameters for its role (e.g. an advice system pretending to be sympathetic) may, for that very reason, appear implausible. In developing teaching and training systems, we have encountered various manifestations of the plausibility problem. For example, systems withholding help deliberately [4], or systems apparently forgetting what has been taught by the human learner in a learning companion system [19], or issues concerned with users’ lack of belief about the capability of the system to deliver what they need, e.g. help of appropriate quality [16].

This paper examines the nature of the Plausibility Problem as a particular example of situations in which an attempt to simulate inter-subjective understanding is made by or through an interactive system (and issues of plausibility thereby arise). The roles explored are taken from educational contexts and include helping and advising as well as evaluation.

We identify three kinds of potential plausibility issue, depending on whether (i) the system is seen by its users to be a machine acting in its own right, or (ii) the machine is seen to be a proxy, either acting on behalf of a human or providing a channel of communication to a human, or (iii) the status of the machine is unclear between the first two cases.

In the first case plausibility is bound up with issues as to whether a machine, as a machine, is acting outside the bounds of what the user, in that context, thinks is reasonable. The second case is much less of an issue for us in that the system is seen as a proxy for a human and therefore any plausibility issue will tend to be associated with the person for whom (or to whom) the machine is a proxy. Of course, there may be issues of the effectiveness of its role as a proxy or of its facilitating communication, but these are not really plausibility issues.

The third case does raise plausibility issues, especially where the user cannot judge whether the machine is acting in its own right or not. In that case, if the user thinks that it is so acting in its own right, when in fact it is just a proxy, the user may regard some behaviour of the system as implausible which might have been regarded as plausible had the behaviour come from a human (or her proxy). Likewise, if the system is thought of as a proxy for a human but is in

fact acting in its own right, an implausibility judgement may be made about the way that the supposed human is acting.

In the days where computers were largely stand-alone, their status as self-contained *vs* being proxy or communication channels was perhaps more clearcut. With the ubiquity of networking, the issue of whether (or to what extent) a system is a proxy is much more complex. This blurring is accentuated by systems which attempt to simulate human face-to-face interactions through the use of animated pedagogical agents, see e.g. [9]. With the rapid improvement in graphical and audio technology these systems can now bring a wider range of more human-like interaction tactics to bear such as a change of facial expression, or a change of verbal emphasis.

This paper is divided into two main sections. The next section provides examples of implausibility judgements where the system is regarded as a machine acting in its own right, case (i) above. The second section looks briefly at examples where plausibility judgements are bound up with uncertainty about the status of the machine, case (iii) above.

## **2 It's just a machine — and machines should not do that**

### **2.1 Human teachers can say that, but not machine teachers**

Del Soldato [3, 4] implemented various of the motivational tactics, e.g. derived by [10–13] in a prototype tutor to teach rudimentary debugging of Prolog programs. Included in her system was a set of (motivational) rules intended to maintain the students' sense of confidence and control. These rules might suggest easy problems to a student who needed a boost in confidence, or might be rather 'firmer' with students who had not exhibited much effort and also seemed self-confident.

The system (MORE) was evaluated by comparing a version with the motivational rules switched on with one where they were disabled. The version using motivational rules was generally liked by students but two negative reactions from students are noteworthy. One of the rules in the system was designed to prevent the student prematurely abandoning a problem and moving on to the next one, if the system believed that the student was not exhibiting enough "effort", as measured by the number of actions the student had taken in the partial solution.

"One subject was showing signs of boredom from the start of the interaction. . . . After a little effort trying to solve a problem, the subject gave up and the tutor encouraged him to continue and offered help. The subject kept working, grumbling that the tutor was not letting him leave. When comparing the two versions of the tutor he recalled precisely this event, complaining that he had not been allowed to quit the interaction."  
[3](page 77)

Further rules were concerned with deciding how specific a help message should be delivered in response to a help request — not dissimilar to the rules

in Sherlock, see e.g. [14], or indeed to the Contingent Teaching strategy [21]. However in some circumstances the help system refused to offer any help at all in response to a request from the student, in the belief that such students needed to build up their sense of control and that they were becoming too dependent on the system.

“The subjects who were refused a requested hint, on the contrary, reacted strongly against the tutor’s decision to skip helping (ironically exclaiming “Thank you” was a common reaction). Two subjects tried the giving-up option immediately after having had their help requests not satisfied. One case resulted in the desired help delivery (the confidence model value was low), but the other subject, who happened to be very confident and skilled, was offered another problem to solve, and later commented that he was actually seeking help.”

“One of the subjects annoyed by having his help request rejected by the tutor commented: “I want to feel I am in control of the machine, and if I ask for help I want the machine to give me help”. When asked whether human teachers can skip help, the answer was: “But a human teacher knows when to skip help. I interact with the human teacher but I want to be in control of the machine”. It is interesting to note that the subject used to work as a system manager.” [3](pages 76–77)

In both these cases the student was surprised that the system behaved in the way that it did — not we believe because the system’s response was thought to be educationally unwarranted, but because it was “merely” a machine and it was not for it, *as a machine*, to frustrate the human learner’s wishes.

## 2.2 Human students would do that, but not machine students

There is increasing interest in the development of learner companion systems of various kinds, see e.g. [1]. Here the idea is that the human learner has access to a (more or less) experienced, computer-based fellow learner who can either provide help, act as a learning role model, or through its mistakes act as a reflective device for the human learner. For instance, [19] describes a system where the human learner teaches a weaker companion system boolean algebra in order to better understand the topic herself. The learning companion (LC) was not an ‘embodied’ agent, but essentially an unseen entity communicated with via a simple text and push-button interface.

Some care was taken to make the weaker companion act in a realistic way. In particular, it did not always “understand” what the human student tried to teach it, it did not always follow the advice offered by the human student, and it sometimes forgot what it had been taught. Ramirez Uresti notes that some students were “very annoyed to observe that the LC did not ‘learn’ all the concepts that had been so carefully taught to it”. Moreover, this judgement about plausibility had knock-on effects for later in the interaction:

“However, after some teaching incidents, students started to diminish the quality of their teaching until just the rule needed for the current step was taught to the LC. . . . Once students noticed that the LC was not learning quickly they started to teach only one rule instead of a complete heuristic. This combination of teaching all the strategy and then having to teach it again and again may have been detrimental to the perception of the weak LC and of the teaching process. It may also explain why the weak LC was described in the post-test as not very exciting and annoying.” [19] (page 110–111)

### **3 Human teachers can do that, but not machines**

Learners’ expectations are an important factor of the plausibility problem. Increasingly learners are exposed to computers in their learning and in other aspects of their lives. They absorb the cultural computation conventions and facilities for giving help. These build up expectations of the degree of focussed assistance that they might reasonably expect.

In the next example, see Section 3.1 below, the plausibility problem may be responsible for results which confounded expectations. There are a number of differences between this system and those of del Soldato and Ramirez Uresti, described above. It was aimed at school children, specifically designed to be similar to other educational systems they had used and was evaluated in the children’s everyday class. It also explored a topic — simple ecology — that the children were learning at school and, in the versions that decided how helpful to be, was designed to ensure that the child succeeded as far as possible, even if this meant that the system did most of the work.

#### **3.1 A system that ‘wants’ to help**

Three versions of a tutorial assistant which aimed to help learners aged 10–11 years explore food webs and chains were implemented within a simulated microworld called the Ecolab [15]. The system was developed to explore the way in which Vygotsky’s Zone of Proximal Development might be used to inform software design. The child can add different organisms to her simulated Ecolab world and the complexity of the feeding relationships and the abstractness of the terminology presented to the learner can be varied. The simulated Ecolab world can be viewed differently, for example in the style of a food web diagram, as a bar chart of each organism’s energy level or as a picture of the organisms in their simulated habitat. The activities the learner was required to complete could be “differentiated” (i.e. made easier) if necessary and different levels (i.e. qualities) of help were available.

One version of the system — VIS — maintained a sophisticated learner model and took control of almost all decisions for the learner. It selected the nature and content of the activity, the level of complexity, level of terminology abstraction, differentiation of the activity and the level of help. The only option

left within the learner’s control was the choice of which view to use to look at her Ecolab. A second version of the assistant — WIS — offered learners suggestions about activities and differentiation levels. They were offered help, the level of which was decided on a contingently calculated basis [21]. They could choose to reject the help offered or select the “more help” option. The third system variation was called NIS. It offered 2 levels of help to learners as they tried to complete a particular task. The first level consisted of feedback and an offer of further help. The second level, which was made available if the child accepted this offer, involved the assisting computer completing the task in which the child was currently embroiled. Of the three systems NIS offered the smallest number of different levels of help and allowed the greatest freedom of choice to the child. She could select what she wanted to learn about, what sort of activity she wanted to try, how difficult she wanted it to be and then accept help if she wanted it. The choices were completely up to the individual child, with not even a suggestion of what might be tried being offered by the system.

Three groups of 10 children (matched for ability) worked with the three systems. Outcomes were evaluated both through pre/post-test scores on a test of understanding of various aspects of food webs and chains, and via an analysis of what activities the children engaged in and how much help they sought and received. Pre/post-test comparisons showed that VIS produced greater learning gains than WIS and NIS, see [15,18] for details. Our focus here is not on the learning gains but on the help seeking behaviour of the students.

### **3.2 Children who don’t ask for help**

It is clear from the records logged by the systems of each child’s interactions that none of the NIS users accepted the option of seeking more help when offered feedback. There is a clear and typical pattern within the interactions of NIS users: actions are attempted, feedback is given with the offer of help, help is not accepted. The action is re-attempted and once completed successfully it is repeated, interspersed with view changes and further organism additions at differing rates of frequency. Only one of the NIS users asked for a differentiated activity and only two attempted to interact at anything other than the simplest level of complexity or terminology abstraction. The child who tried the differentiated activities chose the highest level of differentiation and once the activities were done he returned to the typical NIS pattern. The help seeking or lack of it is particularly marked in the two children who opted to try the most advanced level of interaction. Both made errors in their initial attempts at completing the food web building action selected, but neither opted to take more help when offered. Few activities were attempted and those that were chosen were accessed with the lowest level of differentiation. The same food web building activity was repeated in both sessions of computer use and in both sessions errors were made. The presence of these errors and the apparent desire to tackle more complex concepts would suggest that the children were willing to move beyond what they already understood. However, the lack of collaborative support restricted their

opportunities for success and their progress was limited. What could have been a challenging interaction became a repetitive experience of limited scope.

Unlike the NIS users, all the WIS users accepted help above the basic level and the majority used help of the highest level and then remained at this level. A typical WIS approach would be to try an action, take as much help as needed to succeed with this action and then repeat it before trying another different action. Activities were requested with differentiation. In the majority of cases this differentiation was at the highest level. Without question the WIS users were more willing to attempt actions with which they were going to need help. There were members of this group who progressed through the curriculum both in terms of complexity and terminology abstraction. This is a direct contrast to the NIS user group.

### **3.3 Why do some children seek help and others not?**

The clear difference between one group's willingness to use help over and above simple feedback (WIS) and the other group's complete lack of help seeking is interesting. The help instances for the NIS users were either simple feedback or a demonstration of the particular action being attempted: equivalent to the highest level of help in WIS or VIS. All but one of the NIS users made mistakes and were given feedback, but none of them accepted the offer of further help. It is difficult to explain this startling lack of help seeking behaviour and any attempts are clearly speculative.

The only difference between the WIS and NIS system with regard to differentiation or the presentation of help is in the way that WIS suggests that the user try a particular level of differentiation for an activity or ask for help. This policy of offering suggestions was not universally successful. WIS users received suggestions about which activities they should try. These were however accepted less often than the suggestions about the differentiation of an activity. If a suggestion was enough to allow the child to accept an easier activity then it seems reasonable to consider the possibility that without the suggestions, the NIS users viewed choosing a more difficult activity as being somehow better and therefore what they should be attempting.

As part of the design of the experiment, note was taken of the computer programs the children had experienced previously. One tentative explanation of the different behaviours is that children did not believe that either asking for more help or for an easier activity would be successful. The WIS users received suggestions and once the higher levels of help were experienced they were taken up and used prolifically. In this sense the WIS system demonstrated its plausibility as a useful source of assistance in a way that the children never gave the NIS system a chance to show.

A further factor which is consistent with this help seeking behaviour is found in the observation that none of the children accessed the system help menu or system help buttons. These were available to explain the purpose of the various interface buttons and the way that action command dialogues could be completed. The children had all used a demo of the system, which allowed them to



determine the nature of the interface and none reported problems at the post-test interview. However, when observing the children using the system it was clear that there were occasions when they were unsure about a button or a box and yet they did not use the help button provided. This may well be an interface issue which needs attention in any further implementations of VIS. However, it may also be part of the same plausibility problem.

### **3.4 Turning to a wizard for help**

In order to further explore children's perceptions about the type of help that computing technology can afford we have subsequently conducted a series of small empirical investigations. Working with children can be difficult: they are less willing and able to express their thoughts and ideas. We therefore used an adaptation of the 'Wizard of Oz' technique: previously used to simulate human computer interfaces with the human 'wizard's' existence being unknown to the user [2]. However, in this case the user and the wizard were working on the same apparatus: a paper-based computer and were able to view each other's interactions continuously. Pairs of children used the paper-based version of the Ecolab software, the one playing the role of the computer; the other the role of the learner. In this way we hoped to elicit information about children's perceptions of the types of help that computers could and should provide for them when using the software to learn about ecology [8,7].

Early results indicate that children can accept the possibility that a computer might be more helpful on some occasions than on others and that this lack of consistency in the 'behaviour' of the technology is not viewed as unacceptable or implausible. Sometimes the children tried to help the 'user' as best they could, on other occasions they chose to make it difficult. For example, one child, when playing the role of the computer preferred to make his learner manage with little help; he explained his selection: "It is the hardest ...and computers are really mean". However, we have yet to see whether or not the replacement of the child 'wizard' with a software implementation will yield the same results. This will raise questions about the 'location' of the implausibility: does it arise from the interface or the wider context in which the interactions occur?

## **4 Is it a machine or a person?**

The nature of a network of computers further clouds the plausibility landscape and blurs the boundaries between when users are interacting with technology and when they may be interacting with other human beings. In contrast to the current HCI impetus for increasing usability through hiding how applications work, there is increasing evidence to suggest that people have a poor understanding of how networked technologies, and in particular the Internet actually work [20]. The Internet is still a relatively new phenomenon that allows data exchange between networks of computers connected via national and international

telecommunications systems to other connected networks that wish to communicate. Thanks to agreed transfer protocols and address standardisation these networks appear seamless to users who can read and download files from remote machines, publish to those using remote machines, communicate via multi-media or use their personal computers as terminals. Whilst this seamlessness has clear benefits, it creates the illusion of a faultless network of connections which is far from the truth. The Internet is unstable, unpredictable and inherently unreliable.

In order to try and ascertain the implications of networked technologies and people's conceptions and misconceptions, we conducted an empirical study with 9-10 year old children. The use of children in this study offered us the opportunity to tackle early understandings and hopefully even pin down when misconceptions and potential plausibility issues might occur. During a series of studies with a class of 9-11 year old children over a two year period we talked to children about their expectations of what the internet would and could offer [17]. The children in this study produced simple representations of the Internet that often focused upon the sort of computer that they were familiar with. There were however many instances in which they included references to the sort of activities that the Internet enables. The most popular facilities children envisaged to be available as a result of the Internet were communication, research or information retrieval using the WWW and — to a lesser, though increasing, extent — the publication of work. Despite the common occurrence of interpersonal communication however, humans were not frequently seen as integral to children's representations of the Internet. However, some children did talk about the internet as an animate object that "knows" things. And yet, when asked about their feelings about publishing their own work on the internet the concerns they raised were only ever couched in terms of their worries about what other people would think about them and their work. Would the spelling and grammar be good enough, for example?

## 5 Conclusions

We have started to map out some examples of the plausibility issue, and tried to show why it is more than simply about designing for a smooth and agreeable interaction. Our examples are taken from education but future work will examine other areas such as advice-giving and e-commerce where similar issues are likely to arise.

This early work does not as yet allow us to draw firm conclusions about when and where the plausibility problem occurs with any precision. It does however, indicate the complexity of the issue and suggest that people's perceptions about what networked technologies can and should do are not consistent, nor are they identical to those that prevail for stand-alone systems. The plausibility problem is a changing and moving target that is not going to disappear as the sophistication and ubiquity of the technology increases.

## References

1. T.-W. Chan. Learning companion systems, social learning systems, and the global learning club. *Journal of Artificial Intelligence in Education*, 7(2):125–159, 1996.
2. N. Dahlback, A. Jonsson, and L. Ahrenberg. Wizard of Oz studies — why and how. In M. T. Maybury and W. Wahlster, editors, *Readings in Intelligent User Interfaces*. Morgan Kaufmann, San Francisco, 1998.
3. T. del Soldato. Motivation in tutoring systems. Technical Report CSRP 303, School of Cognitive and Computing Sciences, University of Sussex, 1994.
4. T. del Soldato and B. du Boulay. Implementation of motivational tactics in tutoring systems. *Journal of Artificial Intelligence in Education*, 6(4):337–378, 1996.
5. B. du Boulay, R. Luckin, and T. del Soldato. The plausibility problem: Human teaching tactics in the ‘hands’ of a machine. In S. P. Lajoie and M. Vivet, editors, *Artificial Intelligence in Education: Proceedings of the International Conference of the AI-ED Society on Artificial Intelligence and Education, Le Mans France*, pages 225–232. IOS Press, 1999.
6. B. Fogg and H. Tseng. The elements of computer credibility. In *Proceedings of CHI’99*, pages 80–87, Pittsburgh, 1999.
7. L. Hammerton and R. Luckin. Children and the internet: a study of 9 - 11 year olds. *Paper to be presented in a workshop at AIED 2001*, San Antonio, Texas, 2001.
8. L. Hammerton and R. Luckin. How to help? investigating children’s opinions on help. *Poster to be presented at AIED 2001*, San Antonio, Texas, 2001.
9. W. L. Johnson, J. W. Rickel, and J. C. Lester. Animated pedagogical agents: Face-to-face interaction in interactive learning environments. *International Journal of Artificial Intelligence in Education*, 11(1):47–78, 2000.
10. J. M. Keller. Motivational design of instruction. In C. M. Reigeluth, editor, *Instructional-design Theories and Models: An Overview of their Current Status*. Lawrence Erlbaum, 1983.
11. M. R. Lepper. Motivational considerations in the study of instruction. *Cognition and Instruction*, 5(4):289–309, 1988.
12. M. R. Lepper and R. Chabay. Socializing the intelligent tutor: Bringing empathy to computer tutors. In H. Mandl and A. Lesgold, editors, *Learning Issues for Intelligent Tutoring Systems*, pages 242–257. Springer-Verlag, New York, 1988.
13. M. R. Lepper, M. Woolverton, D. L. Mumme, and J.-L. Gurtner. Motivational techniques of expert human tutors: Lessons for the design of computer-based tutors. In S. P. Lajoie and S. J. Derry, editors, *Computers as Cognitive Tools*, pages 75–105. Lawrence Erlbaum, Hillsdale, New Jersey, 1993.
14. A. Lesgold, S. Lajoie, M. Bunzo, and G. Eggan. Sherlock: A coached practice environment for an electronics troubleshooting job. In J. H. Larkin and R. W. Chabay, editors, *Computer-Assisted Instruction and Intelligent Tutoring Systems*, pages 289–317. Lawrence Erlbaum Associates, Hillsdale, New Jersey, 1992.
15. R. Luckin. ‘ECOLAB’: Explorations in the Zone of Proximal Development. Technical Report CSRP 386, School of Cognitive and Computing Sciences, University of Sussex, 1998.
16. R. Luckin and B. du Boulay. Ecolab: The development and evaluation of a vygot-skian design framework. *International Journal of Artificial Intelligence in Education*, 10(2):198–220, 1999.
17. R. Luckin and J. Rimmer. Children and the internet: a study of 9 - 11 year olds perceptions of networked technologies. Technical report, School of Cognitive and Computing Sciences, University of Sussex. In preparation.

18. S. Puntambekar and B. du Boulay. Design and development of MIST — a system to help students develop metacognition. *Journal of Educational Computing Research*, 16(1):1–35, 1997.
19. J. A. Ramirez Uresti. Should I teach my computer peer? some issues in teaching a learning companion. In G. Gauthier, C. Frasson, and K. VanLehn, editors, *Intelligent Tutoring Systems: 5th International Conference, ITS 2000, Montreal*, number 1839 in Lecture Notes in Computer Science, pages 103–112. Springer, 2000.
20. L. Sheeran, M. Sasse, J. Rimmer, and I. Wakeman. Back to basics: Is a better understanding of the internet a precursor for effective use of the web? In *NordiCHI, Stockholm*, 2000.
21. D. J. Wood and D. J. Middleton. A study of assisted problem solving. *British Journal of Psychology*, 66:181–191, 1975.