Marching to the Wrong Distant Drum: Pedagogic Agents, Emotion and Student Modelling

Paul Brna and Bridget Cooper
Computer Based Learning Unit
Leeds University
Leeds LS2 9JT, England
tel: +44 113 233 4637
fax: +44 113 233 4635
email: paul,bridget@cbl.leeds.ac.uk

Liana Razmerita
Computer Science Department
University "Dunarea de Jos" Galati
Romania
email: Liana.Razmerita@ugal.ro

Abstract

In the last few years there has been a strong growth of interest in pedagogical agents. Typically, these agents are represented to learners as simulated beings (dogs, bugs, ants, humans) existing in some virtual environment. Along with this new way of communicating with children there has been a corresponding rise of interest in emotional agents, agents that manifest some behaviour based on an underlying simulation of emotional state and rules that govern transitions from one state to another. Combining these two concepts, we now have the notion of emotional pedagogical agents.

In this paper, we argue that this research direction is certainly a difficult one but may also be perilous. We sympathise with the research goal of modelling humans in the round, adding an emotional component to existing models of cognitive and sensorimotor behaviour. We can happily pursue this activity as a research goal which should lead to many interesting discussions even though we argue that adding an emotional component to a core cognitive model will not lead to a convincing model of a person, and may lead quickly to a research dead end.

1 Introduction

We are concerned about the kind of emotional pedagogical agent which seems to be the focus of current research attention. Namely, one that interacts with learners, passing through a fairly wide range of human emotions according to the behaviour of the learners and perhaps some situational factors as well. It may be easy to do this, and there is still a strongly seductive drum beat to the call to model the whole human being. It is almost certainly dubious, possibly dangerous if the pedagogical agent represents (acts on behalf of) the teacher, and if the pedagogical agent does not possess 'higher order' emotional behaviour. By higher order emotional behaviour, we mean reflection on one's own emotional state and the emotional states of learners, and self regulation of the expression of one's own emotional state and support for the emotional state of the learner.

This position has been developed as part of our work on the Networked Interactive Media in Schools (NIMIS) project. NIMIS is an international project funded by the European Union and is part of the ESE (Experimental School Environments) group of projects. NIMIS takes a 'whole' approach to the use of ICT in learning. It envisages a classroom of the future through the development of hardware and software designed to develop collaborative skills, perspective taking and narrativity and literacy skills in pupils from 5–8 years. This paper focuses on the work of the UK team based at Computer Based Learning, Leeds University and their work with a North Yorkshire Primary school, where the classroom of the future they have created is situated in an otherwise normal infant class of five and six year olds. The intelligent agent 'Louisa' has recently been embedded in

newly designed software, T'rrific Tales, which enables these young children to write multi-media cartoon style stories individually or collaboratively. We use the process of designing Louisa to illustrate the need to follow a different drum beat for the development of pedagogical agent.

We end by considering the prospects for student modelling techniques in developing pedagogical agents which manage the cognitive, sensorimotor and affective health of the children for which the agent is responsible.

2 Theoretical Framework

Recent developments in neuroscience have reconfirmed the importance of affect in learning. The work of Damasio (Damasio, 1994), Goleman (Goleman, 1995) and others has re-emphasised the interrelated nature of learning, the subtle affective elements in all decision-making and learning processes. The importance of affect is implicit in the everyday relationships between teachers and learners in classrooms (Cooper, 2000)

Our approach is to develop agents that have to operate within an area of shared understanding which encompasses both the teachers perspective, the child's perspective and the dynamic context in which the learning takes place, linking the 'whole' cognitive and affective experience of the learner in an attempt to meet their needs more effectively. Though an artificial tutor coupled with a believable agent cannot really empathise with or understand the students to whom it responds, it can demonstrate empathic characteristics, which improve the learning climate and help to meet the individual learning needs of students. Research in artificial intelligence and collaborative learning has already identified a range of empathic characteristics such as positive affirmation and understanding (Zimmer, 1995; Cooper *et al*, 2000), motivating aspects of facial expression, voice tone and body language and creation of a persona in combination with knowledge-based learning environments (Rickel & Johnson, 1999a) to help identify and meet learning needs in the right way at the right time.

Recent research into children's response to avatars showed the particular importance of the listening response and the significance of envelope behaviours (Cassell & Thórisson, 1999) which are also key empathic characteristics. Increasingly research in artificial intelligence is examining the teaching and learning process in a more complex way (sometimes in a more complex way than traditional educators). Such research has considered switching different roles in response to the student by considering both the affective and cognitive elements in learning (duBoulay *et al*, 1999) and the combination of peer and tutor roles (Goodman *et al*, 1998).

Louisa is being developed to model empathic and more equal relationships in the classroom and to support the development of literacy, narrative, collaborative and interpersonal skills. The children and teachers were observed and consulted about her development. Ultimately the children might have a choice of characters for the agent but one suggestion was a 'nice' girl and she became the prototype agent. Louisa is an older child because older children are seen as more helpful (Kyriacou, 1986). The aim wasn't to make her believable in herself but to give her certain qualities in relation to the way she responds to children. It is this 'interaction dynamics' that we regard as having the primary importance from the perspective of the framework we have developed.

3 Pedagogical Agents that Care?

Animated agents used for pedagogical purposes are an attractive new paradigm for exploration. Research in pedagogical agents involves a multidisciplinary approach, which includes: psychology, pedagogy, distributed computing, artificial intelligence, linguistics, etc. Animated pedagogical agents that are able to gesture, smile, speak, expressing a range of emotional expression provide the promise of a technology that should deliver improved qualities of tutorial communication and increasing learning environments' ability to engage and motivate students (Johnson *et al*, 2000)

Current research includes work primarily on cognitive issues via Steve and Adele at USC-ISI (Johnson *et al*, 1998; Rickel & Johnson, 1999b; Shaw *et al*, 1999). Herman the Bug at the University of North Carolina in the USA (Lester *et al*, 1997) uses an animated character to motivate learning. One pedagogical agent that has some emotional dimension is being investigated by Clark Elliott as part of the Affective Reasoning Project at DePaul University (Elliot, 1997) However we are arguing for agents that can manage the emotions of others rather than ones that model the full range of emotional variability found amongst people in general!

As we have already argued, the requirements placed on pedagogical agents are demanding if these agents are to participate within a framework that models the empathic and sensitive relationships that hold between an effective teacher and students. This places significant additional demands on pedagogical agents compared with many synthetic characters found in other research areas even though many issues in the general area of autonomous agents are common ones.

The current level of sophistication in the generation of synthetic agent characters is technically impressive. However, the successes in generating 'believable' behaviour have been less so in that the social roles modelled have often been very impoverished, making few demands on a person to engage at an empathic level with the user (e.g. someone at a checkout, disinterested bank clerk, bored bartender). Nevertheless, many researchers still seek to construct synthetic agents, which can participate in highly plausible relationships with users and with each other (Elliot & Brzezinski, 1998).

Our approach is that pedagogical agents should have some knowledge of the students that goes beyond the current session, exemplify characteristics which we would like our students to possess (patience, tolerance, appreciative, valuing, kind, concerned, helpful), and be engaged in their own work. They should also have some knowledge of the domain, how to teach and, ideally, some knowledge of the cognitive and affective issues involved.

4 Designing a Pedagogical Agent

Empathic agents don't just happen. People become empathic through experiences with other caring agents who model empathy to them in many ways —- both verbal and non-verbal. People grow up in a social context within which empathy plays an important part in helping children to grow up and realise their potential.

Pedagogic software agents built without an underlying model of empathy are very unlikely to react coherently in relation to learners. Many research years of effort can be wasted by taking the line that if only we can get the behaviour of an individual agent right then we will be able to 'add on' the desired empathy module. While there are many ethical problems connected with the simulation of empathy, there are perhaps more profound problems with the approach that argues that we produce our agents within a framework which has no explicit reference to the empathic.

So from this perspective, the design of a pedagogic agent requires early consideration of empathy before even considering how emotionally complex the pedagogical agent needs to be. It is also necessary to consider the nature of the interactions which can be sustained by the agent, and what evidence can be adduced by the agent which can usefully be used to support a high quality interaction. In our own work, we have approached the design of Louisa via a form of participant design (Carroll & Rosson, 1992; Chin *et al*, 1997; Cooper & Brna, 2000).

We can demonstrate the approach with reference to our own progress in designing Louisa, a pedagogical agent designed within a strongly empathic framework. In order to provide contextual and personalised support, our prototype agent Louisa is designed to encourage children to elaborate their story, the narrative provided by their cartoon frames. Louisa suggests possible solutions when they get stuck. She exhibits a friendly behaviour. She models a positive attitude to work: she works quietly; a Java animation shows her working at a Wacom tablet. If the children need her they can click on her image. She then stops her own work, turns and gives her message in both text and speech.

In Figure 1 there is an an example of an intervention by Louisa. The child creates a fairytale scene in a throne room where there is a queen, a king and some jewels. Using these elements and a predetermined set of goals, Louisa selects the plan to be achieved. Louisa engages in a discourse, asking questions or making particular remarks which are intended to concentrate the children on thinking more about their story cartoon, writing more and/or better — i.e. improving and extending the story. In our case, to do this, Louisa asks open questions relating to the description of their own cartoon frame (e.g. "That's a good beginning... What happens next?"). For motivating the children, Louisa makes positive comments/qualifications (e.g."That's a nice story!"). Louisa generates interventions by giving the children ideas about what to do in order to develop their narrative (e.g. "Say more about the king!"). Louisa suggests different actions, goals (e.g. "I am curious to see how your story ends!"). If there is no writing in the text area the agent says hello to the child, calling their name and after that she explains to the child that she is writing a story too and she asks the child "Do you want to write a story?".

5 User Modelling and Interaction

The scope for deriving models of the user from interactions between children and with an agent varies from context to context. Human-Agent Interaction (HAI) in T'rrific Tales has been designed to allow for differences between users/children. It also takes into account the different possibilities available in group learning contexts, and the model of pedagogy adopted by the childrens' teachers. In our case, HAI can be seen as a form of dialogue dependent on a certain scenario — the context of the interaction with the application. The children's interactions with the T'rrific Tales environment can be classified in terms of: actions, activities, and transitions between activities.

Children work in six basic spaces: Background Space; Character Space; Props Space; Word Space; Story Picture Space and Story Text Space. The activ-

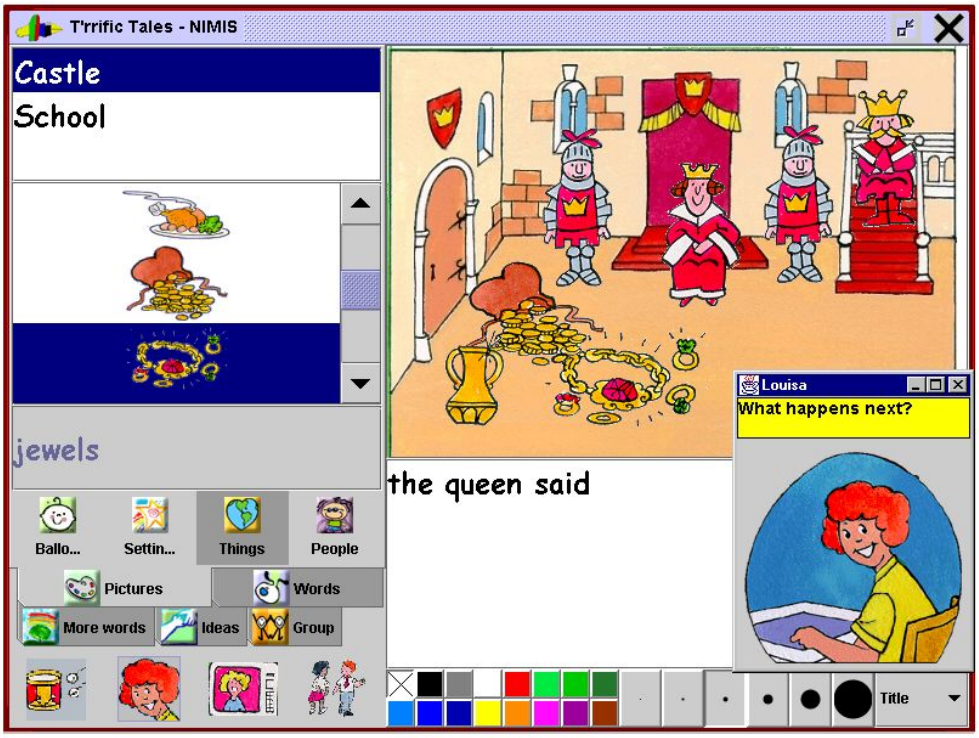

Figure 1: Louisa at Work

ities that take place within these spaces are core ones; other activities could be seen as composed out of these together with some transition between them. For example, Cartoon Frame Space is regarded as involving both Story Picture Space and Story Text Space and transitions between them while Cartoon Space is seen as the set of all six of the Cartoon Frame Spaces together with the relevant transitions. The user model and the agent's knowledge is closely related to the children's activities and to the application's context. In the Terrific Tales application, these knowledge elements are: backgrounds, props and characters of the story cartoon, written text, etc.

At this stage of the project the agent builds a shallow student model based upon relatively short-term interaction with the system. A "deeper model" of the student will take into account interaction patterns, short-term intentions and preferences inferred from children actions, activities, and transitions between activities.

It is also planned to take into account the different level of user expertise in story writing, which could be associated with their reading age. For children at a lower attainment level in terms of reading age more guidance should be provided relating to the story writing process, more questions relating to what is happening in their cartoon, about their characters and about the plot of the story. We think that the agent's interventions should be less frequent for children of a more advanced reading age but on-line support and suggestions should be of a more detailed nature.

6 The Potential of Empathic Agents

Louisa is used as an example of an early stage of the design of an empathic agent. Empathy is 'built in' from the beginning and as the design is elaborated more components are added relating to helping children learn. This process could in principle be continued using detailed information about the cognitive, social and affective state of the child.

As an example of a pedagogical agent, Louisa is envisaged as a link between the computer and child, the subject domain and child and the child's' peers, and the teacher and child. The agent provides security and support, offers development and opportunities for learning in a positive and non-intrusive way. She does not see the child as an isolated learner but as a member of the larger group in the classroom and assumes other support. She tries to provide support at the right moment but in a guiding and suggestive fashion rather than a controlling or dominating way.

The capability of the current version of Louisa is in-

evitably limited — in part, because Louisa is designed to be no more powerful than it need be. Louisa is limited, as are all such agents, in terms of what she can perceive, what interpretations of this can be made and what conclusions she can draw.

There are open questions and future work related to the possibility of creating an adequate deep student model inferred from the student's actions, activities and transitions combined with other 'external' sources like the child's name, reading age and previous work done. On the other hand, a more varied range of deliberative agent intervention could provide the user with an engaging and enjoyable experience and better support. In taking Louisa forward, we believe that the combination of the two aspects mentioned above could create an empathic and stimulating relation between the agent and the students, enhancing T'rrific Tales as a learning environment.

7 Conclusion

We started by pointing out that the trend is to develop agents which can exhibit emotion, and perhaps, plausible behaviour. We have highlighted our concerns through a discussion of some of the issues that have motivated us.

We have used Louisa to illustrate four specific kinds of empathic behaviour that need to be 'designed in'. It must be emphasised that each of these specific kinds of behaviour can be realised in a number of ways which are aspects that the empathic teacher will manifest. Since Louisa is an agent of the teacher, it is important that Louisa manifests them too. However here we argue that there are six important aspects, and that Louisa, as yet, does not fully manage the fifth aspect but does manage the sixth.

Attend: The empathic teacher (and agent) stops doing what they want to do, thinking what they want and expressing their own emotions and turns to consider the actions, thoughts and feelings of the learner. Here, we indicate the importance of attending to affect, cognition and sensorimotor issues.

Engage: The teacher begins to align their actions, thoughts and feelings with those that the child is experiencing. The teacher makes it clear that this is going on.

Value: The teacher, by actions, words and the expression of appropriate emotions, makes it clear to the learner that they and their work is considered to be valuable to the teacher.

Encourage: The teacher then seeks to encourage the child to go further. This encouragement has emotional, physical and cognitive aspects.

Parting: The teacher now turns to another matter, the work she was previously doing, or to the needs of another child. The link with the child is not broken, and 'closure' is not sought. This is achieved by a combination of gesture & facial expression, comment and feeling, and indicates the availability of the teacher for later interaction. In a sense this fifth part is implicitly managed by Louisa because she is always available for consultation. More directly she might smile and suggest that she can be called if needed.

Available: The teacher is working at their own work — usually with other children in the class — but is ready to be available whenever needed. The teacher quietly supports the child. The agent is not as limited as a human teacher in that an agent has no requirement to manage a class of children and can in practice be interrupted at any time. This allows a good climate to be developed in the classroom freeing the human teacher to give high quality care.

This continued availability is central to the ethical and caring standpoint we have adopted. At the outset, the teacher is available (before attending) and at the end after returning to their work. This implication of further support is crucial to the teacher's success, implying care, concern, continuity, support, security — there will always be someone there to value the work even if other children or the teacher are busy. She may not even be used but she is there — her being there allows progress because she imbues confidence and is a symbol of value even if no interaction takes place. The quality of the support is crucial.

Surrounding all these (six) aspects there is the key idea that the teacher (and software agent) models physical actions, thinking and emotional behaviour that the teacher wishes that the learner exhibit. The teacher (and agent) have a responsibility to do so. There is an ethical system at work.

The challenge to those who seek to develop emotional agents is to achieve this higher level of behaviour, and explicitly fulfil the responsibility that the agent's implementer has to provide an agent that models desirable physical activity, ways of thinking and emotional behaviour.

Acknowledgements

This work was supported by the EU funded Networked Interactive Media in Classrooms (NIMIS) project no 29301. Our thanks to the whole NIMIS team with particular thanks to Keith Holder, Bill Rudling, Judy Robertson, Heather Rix, Daniela Romano, Sally Freytag, Ilona Gates, Dawn Liversidge, Andrew Kellington, Val Ashdown and the teachers and children at Glusburn Primary School.

References

Carroll, J.M. and Rosson, M.B. (1992). Getting around the task-artifact cycle: How to make claims and design by scenario. *ACM Transaction on Information Systems*, 10:181–212.

Cassell, J. and Thórisson, K. (1999). The power of a nod and a glance: Envelope vs. emotional feedback in animated conversational agents. *Applied Artificial Intelligence*, (4/5):519–538.

Chin, G. Jr., Rosson, M.B. and Carroll, J.M. (1997). Participatory analysis: Shared development requirements from scenarios. In Pemberton, S., (ed.), *Proceedings of CHI'97: Human Factors in Computing Systems*, pages 162–169.

Cooper, B. and Brna, P. (2000). Classroom conundrums: The use of a participant design methodology. *Educational Technology & Society*, 3(4):85–100.

Cooper, B. (2000). Exploring moral values — knowing me knowing you - aha — rediscovering the personal in education. In Best, R., (ed.), *Perspectives on Personal, Social, Moral and Spiritual Education*. Cassell, London.

Cooper, B., Brna, P. and Martins, A. (2000). Effective affective in intelligent systems — building on evidence of empathy in teaching and learning. In Paiva, A., (ed.), *Affect in Interactions: Towards a New Generation of Computer Interfaces*, pages 21–34. Springer, Berlin.

Damasio, A. (1994). *Descartes Error*. Macmillan, London.

du Boulay, B., Luckin, R. and del Soldato, T. (1999). The plausibility problem: Human teaching tactics in the 'hands' of a machine. In Lajoie, S. and Vivet, M., (eds.), *Artificial Intelligence in Education: Open Learning Environments: New Computational Technologies to Support Learning, Exploration and Collaboration*. IOS, Amsterdam.

Elliot, C. and Brzezinski, J. (1998). Autonomous agents as synthetic characters. *AI Magazine*, 19(2):13–30.

Elliot, C. (1997). Integrating affective computing into animated tutoring agents. In *Eighth World Conference on Artificial Intelligence in Education (AI-ED'97), Workshop V: Pedagogical Agents*. Nagoya, Japan.

Goleman, D. (1995). *Emotional Intelligence*. Bloomsbury.

Goodman, B., Soller, A.L., Linton, F. and Gaimari, R. (1998). Encouraging student reflection and articulation using a learning companion. *International Journal of Artificial Intelligence in Education*, 9:237–255.

Johnson, W.L., Rickel, J., Stiles, R. and Munro, A. (1998). Integrating pedagogical agents into virtual environments. *Presence: Teleoperators and Virtual Environments*, 7(6):523–546.

Johnson, W.L., Rickel, J. and Lester, J. (2000). Animated pedagogical agents: Face-to-face interaction in interactive learning environments. *International Journal of Artificial Intelligence in Education*, 11:47–78.

Kyriacou, C. (1986). *Effective Teaching in Schools*. Blackwell.

Lester, J., Converse, S., Kahler, S., Barlow, T., Stone, B. and Bhogal, R. (1997). The persona effect: Affective impact of animated pedagogical agents. In Pemberton, S., (ed.), *Proceedings of CHI'97: Human Factors in Computing Systems*, pages 359–366.

Rickel, J. and Johnson, W.L. (1999a). Animated agents for procedural training in virtual reality: Perception, cognition, and motor control. *Applied Artificial Intelligence*, 13:343–382.

Rickel, J. and Johnson, W.L. (1999b). Virtual humans for team training in virtual reality. In Lajoie, S.P. and Vivet, M., (eds.), *Artificial Intelligence in Education — Open Learning Environments: New Computational Technologies to Support Learning, Exploration and Collaboration*, pages 578–585. IOS Press, Amsterdam.

Shaw, E., Johnson, W. and R. Ganeshan, R. (1999). Pedagogical agents on the web. In *Proceedings of the Third International Conference on Autonomous Agents*, pages 283–290.

Zimmer, R. (1995). The empathy templates: A way to support collaborative learning. In Lockwood, F., (ed.), *Open and Distance Learning Today*, pages 139–150. Routledge, London.