# Intelligent Agents: An Education System For The Year 2003

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## Introduction

This paper proposes an education system for the next decade that does not have specific classrooms, real or virtual. The basis of this education system is a mentoring, just-in-time learning approach achieved with the help of new and emerging technology.

The use of mentoring and just in time learning is not new. As long as there have been parents and children there has been the modelling of preferred behaviour and ongoing advice on a day-to day basis related to the readiness of the child.

There is also a recorded biblical example set by the life of Jesus Christ (and by the Holy Spirit). The life of Jesus provides an excellent example of the Vygotsky, Zone of Proximal Development concept, involving the interaction between learner, teacher, knowledge and a problem that the learner is trying to solve (Tiffin & Rajasingham, 1995, p24). Jesus called the disciples to follow Him and then proceeded to put them in problem situations and mentor them through the learning process. He, at times, taught them directly as outlined in the gospel of Luke, 'And beginning with Moses and with all the prophets, He explained to them the things concerning himself in all the scriptures.' (NASB, 1977, Luke 24:27). He often proposed problem situations and answered questions with other questions or parables to encourage the disciples to discover the knowledge he was sharing with them (see NASB, 1977, Matthew 21:28-43). The effect of this type of learning is clearly seen in Acts 4 verse 13 where people were impressed by how much the disciples knew. 'Now as they observed the confidence of Peter and John, and understood that they were uneducated and untrained men, they were marvelling, and began to recognise them as *having been with Jesus.'*

Without formal education, the disciples were able to debate with the most learned of the time as a result of only a couple of years with Jesus. After Jesus had been crucified and rose again, he provided another assistant to carry on the teaching process. The Holy Spirit is revealed as the ultimate in just-in-time learning as can be seen in the following quote from Luke 12 verses 11 and 12. 'And when they bring you before the synagogues and the rulers,

and the authorities, do not become anxious about how or what you should speak in your defense, or what you should say; for the Holy Spirit will *teach you in that very hour* what you ought to say.' (NASB, 1977).

The biblical example is that mentoring and just-in-time learning provides for a potentially powerful education system. How can we make use of the technology of today to emulate that process and design an education system for the next decade? What is needed is a knowledgeable assistant who can guide, and teach, at the time the student is ready for the learning – an intelligent agent.

## What is an Intelligent Agent

The idea of agents is not new. Over the decades, researchers from a wide range of fields have studied problems that demonstrate some type of agent behaviour (Riecken, 1994, p20). According to Pattie Maes of MIT, intelligent agents 'are computational systems that inhabit some complex, dynamic environment, sense and act autonomously in this environment, and by doing so realize a set of goals or tasks that they are designed for.' (Maes, 1995, p108). These autonomous agents can have different appearances depending on the environment they exist in. If the environment is the real physical environment, then the agent takes the form of an autonomous robot. There are also 2D or 3D animated agents which inhabit simulated physical environments and 'knowbots.' which are software agents or interface agents which inhabit the digital world of computers and computer networks (Maes, 1995, 108).

There is a range of characteristics of agents derived from the various descriptions. They are considered autonomous, have the ability to 'take the initiative' and can formulate their own goals and to act in order to satisfy them (De Diana & Aroyo, 1999).

Another characteristic agents have is their ability to communicate with other agents and with humans. The communication may be in the form of text commands or more recently speech and even gestures (Maes, 1995, 110)

The ability to learn, mentioned later in this paper is also seen as an intelligent agent characteristic, as is their ability to perceive their environment, and respond to changes that occur (De Diana & Aroyo, 1999).

## The Teaching Agent

The type of agent we are most interested in is the teaching agent that must have a combination of skills. In some cases, it will be required to be a 'knowbot' providing the interface between learner and the huge amount of information. On other occasions, the agent needs to 'inhabit' the learning environment of the student, mentoring them through the material they need to be learning. In this situation the agent has to be aware of its

environment. It has to decide what to do next in order to provide information or teach the learner the next step in their learning.

Prior to 1982, teaching by computer was relegated to the field commonly known as computer-aided instruction (CAI) (Kopec & Thompson , 1992 p93). As more versatile software emerges, the boundary between basic computer aided instruction and more intelligent systems has been blurred. In many of the current CAI packages the software tries to match the level of training to the learners skill. It has to assess the learners skill and adjust the learning to that level. Compared with artificial intelligent (agent) systems the user interaction is still too restrictive, 'limiting the student's expressiveness and thereby limiting the ability of the tutor's diagnostic mechanisms' (Kopec & Thompson , 1992, p94). The CAI software has a limit based on generalised responses to questions. The intelligent agent has a different approach.

Agent based education opens up whole new and exciting areas of possibility because the agent does not simply teach. The intelligent agent is more than just the teacher, it is also the learner. It adapts to the changing needs of the student, their environment and learning style. The agent builds up a character map of the learner in the same way that classroom teacher does.

The technology is here now that makes it feasible to have a personal computer assistant that keeps building a database of everything you do, including continuous real-time videos. 'Soon, perhaps, it could also record vast stores of information about the state of your brain while you did things. Perhaps, in your wristwatch, or in a permanently implanted nanotechnological computer module' (Riecken, 1994b, p25).

This collection of data can allow for 'autonomous agents' to implement a complementary style of interaction, which has been referred to as indirect management. Instead of user initiated interaction via commands and/or direct manipulation, the user is involved in a cooperative process in which human and computer agents both initiate communication, monitor events and perform tasks (Maes, 1994, p31). The concept is not dissimilar to the dyadic relationship between apprentice and master or a classroom dyad where the student 'may turn to a fellow student or call on a teacher to ask for help' (Tiffin & Rajasingham, 1995, p64)

The agent can adapt to the particular learning approach giving 'explanations' for its reasoning and behaviour in a language the user is familiar with, with reference to past examples similar to the current situation. For example, 'I thought you might want to take this action because this situation is similar to this other situation we have experienced before, in which you also took this action.' or 'because assistant Y to person Z also performs tasks that way, and you and Z seem to share work habits.' (Maes, 1994, pp32 - 33).

According to Maes the learning agent gains competence by continuously 'looking over the shoulder.' of the user as the user is performing actions. The interface agent can monitor the activities of the user, keep track of all of his or her actions over long periods of time (weeks or months), find regularities and recurrent patterns and offer to automate these. (Maes, 1994, 33). The agent also has the ability to offer incidental training and mentoring when gaps appear in the knowledge of the user at just the right moment.

## Mentoring, Just-in-Time Learning and Agents

Vygotsky's ZPD concept reinforces the importance of the principle of readiness. The readiness principle relates to the need for a learner to be at a point of readiness for learning certain material. In some cases the window of learning for an individual learner might be a narrow one. The use of intelligent agents for mentoring and just-in-time learning provides the ability to respond to the readiness and get the most efficient and effective learning to take place. Physical classrooms remove the student from their practical learning environment and place them in an artificial learning environment where the learning follows someone else's agenda with minimal adaptation to the readiness of the individual learner. The classroom time constraints also hinder both the learning and the application of the learning. This is pointed out by John Tiffin and Lalita Rajasingham 'In the classroom system a learner can easily get a teacher's attention to solve problems and provide assistance, but this assistance is only possible during class time (Tiffin & Rajasingham, 1995, p154). One suggested solution involves a network of teachers around the world set up as 'teleteachers' accessible to the learners at any time but able to 'focus the instruction on their specific needs'. Another solution for the just-in-time learner is the use of a virtual teacher (Tiffin & Rajasingham, 1995, p148). If the virtual teacher were not a teacher at all but an autonomous, intelligent agent, then the learner is able to get their learning at exactly the time they need it. The intelligent agent, unlike the virtual teacher who is looking after many more students, is able to build up an intricate knowledge of the student and provide much more targeted and timely learning. A virtual teacher that is not always 'present' has no way of closely monitoring success or failure and may miss the process issues. The weaknesses of traditional correspondence school still exist in this format. Take handwriting as an example. A student might be forming the letters perfectly but using an extremely inefficient action to do it. The result looks fine, but potentially restrictive habits may be being established.

## Current Level of Agent Development

We are already familiar with the precursor to agents in the form of wizards, help and the office assistant in

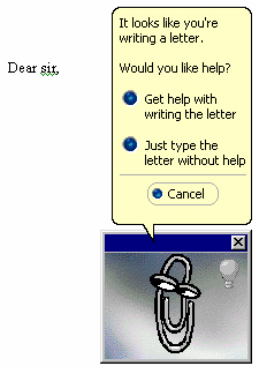
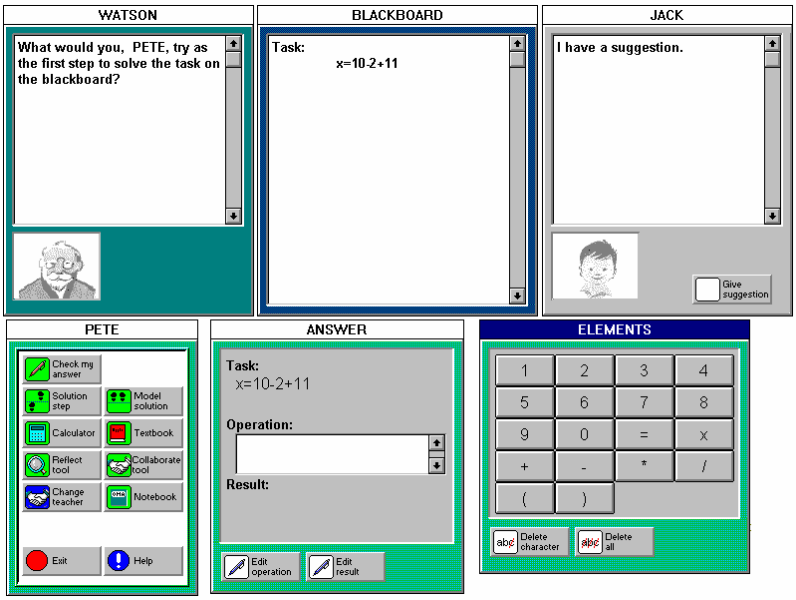



Figure 1 Screen shot of Microsoft Word and Office Assistant

Microsoft products. Although these systems are not intelligent, they are already 'out there' and it is only a small step to systems that get to know you and train you in some way. If you start a word processing document with the words, 'Dear sir' the assistant figures out you are writing a letter and asks if you need help (Figure 1). If you say 'yes' the assistant invokes the wizard to walk you through the process or activates the help system to give suggestions while you work your way through the process. The system that monitors your behaviour and provides more individualised teaching is only a small variation away.

A more intelligent agent is a prototype system produced in 1995 that includes a teacher agent, the knowledge needed and a fellow student (agent) who watches what you do and makes more suggestions on the way (Figure 2).

Figure 2 *Here a learner (Pete) is working with a teacher agent (Watson) and a companion agent (Jack) to solve a task (*Hietala & Niemirepo, 1996).




This learning environment is targeted at a particular subject but it could just as easily be ported across to other areas.

One of the driving factors for development in this area is the increasing number of computers in everyday life. In association with this trend is the increasing number of untrained people interacting with computers, and this number will continue to rise. (Maes, 1994, p31) What this has done is kickstart the agent business. Some of the agents are more entertainment value than learning value like the ALIVE project which is a virtual environment that allows wireless full-body interaction between a human participant and a virtual world inhabited by animated autonomous agents. (Maes, 1995, 110).

More business oriented agents are already available as can be seen from the following list summarised from a research review by Brendan Berney of Manchester Metropolitan University (Berney, 1999);

***Pleiades Project*** *is concerned with the development of a Multi-Agent Architecture in which agents with specialised abilites and knowledge collaborate to provide solutions to a problem.*

***ADEPT project****. This project uses collaborating agents to help in business decision making where he information needed is often spread through several companies in different databases.*

***Calendar Agen****t - This agent assists the user in planning meetings by watching user actions within a scheduling package. Over time, the user's habits are learned.*

***Remembrance Agent*** *- This agent acts as a memory aid.*

***Open Sesam****e - This system is a general purpose personal assistant offering features from file management/retreival to email filtering. This system uses both rule-based and neural network techniques for learning.*

***Oval*** *- An early information filtering agent*

***NewT*** *- The purpose of this agent is to filter pertinent information from newsgroups.*

***Maxims*** *- Based upon the same generic learning agent as the 'Calendar Agent', Maxims learns the user's habits in dealing with email.*

***UCEgo*** *- This agent works in the background in a Unix environment, and is designed to help people master the complexities of Unix. It will watch a users actions and is capable of planning responses to help a user out of trouble.*

***Julia*** *- Julia is an agent that helps users find their way around a Multi User Domain. She is unusual in that she uses a natural language interface to communicate (and as such has often been mistaken for a real human by other 'MUDers'). In user tests, she has been found to be extremely helpful as a guide to both new and seasoned players.*

***Letitzia*** *- Letizia is a user interface agent that assists a user browsing the World Wide Web. The agent tracks user behavior and attempts to anticipate items of interest by doing concurrent, autonomous exploration of links from the user's current position.*

> ***Yenta*** *- Every user runs their own copy of Yenta, and the various Yentas communicate with each other, arranging introductions between their users for people who share interests, novices trying to find experts in a field, and so forth.*
>
> ***Firefly*** *- Firefly is a personal software agent capable of communicating with other users and recommending music that it knows the user will enjoy.*
>
> ***Kasbah*** *- Although not yet implemented, this agent system hopes to buy and sell items on a user's behalf. Kasbah agents will 'meet' in a virtual marketplace and, based on learned user interests, will look through advertisements to find items that they will then attempt to buy.*
>
> ***Internet Softbot*** *- a customizable and (moderately) intelligent assistant for Internet access. The softbot accepts goals in a high-level language, generates and executes plans to achieve these goals, and learns from its experience.*

With only a little imagination, the combination of some of these existing agents could revolutionise the way we learn. We could have our own personalised 'LearnBot' to assist, guide, mentor and advise. The function of an education system to transmit, store and process can all be achieved using networked agents.

## Final Comments

There are issues that impact on both the individual and the institution in relation to the use of intelligent agents as educators.

The ownership issue is probably the most significant. Most of the research and development in this area is still in the domain of the universities and academic associations. As can be seen by theMicrosoft's office assistant development, the release to the wider community is likely to be in the hands of commercial not academic interests. Ownership of the process of education could be commodified to the point of needing to buy teaching agents in the same way that people buy Sony Playstation software or videotapes.

Abandoning control to a programmed robot is not something that will be easy and inertia will probably have a lot to do with the adoption speed of the technology.

Along with their benefits and capabilities, the agents also come with the potential for social mischief, for systems that run amok, for a loss of privacy, and for further alienation of society from technology through increasing loss of the sense of control (Maes, 1994, p33).

More research still needs to be carried out into methodologies for design and implementation, inter-agent coordination in problem solving, collaborative learning theories, verification of systems to make sure that they are stable, and performance issues.

Agents have the realistic advantage of being a true mentor for learning. They allow for 'Learning by doing' as opposed to, for example, conventional textbook instruction. Agent technology has the capability and potential for revolutionising learning and teaching. With all the criticisms, I believe we are on the threshold of a whole new education system that is not based on teachers or even institutions, but on intelligent agents providing just-in-time mentored learning.

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