MSc in e-Learning Dissertation

'Activity in Context' – Planning to Keep Learners 'in the Zone' for Scenario-based Mixed-Initiative Training

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DECLARATION

I declare that this dissertation was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

Austin Tate

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ABSTRACT

My area of interest is “mixed-initiative” approaches to education and how they might be supported by intelligent systems. Traditional education has often been seen as teacher led, with a predefined body of knowledge in some domain to be conveyed via instruction. But some educators advocate a student driven approach of knowledge construction through experience of the world initiated by exploration. Debates about appropriate pedagogy have swung between these two alternative models, different practices giving different emphases to the role of the teacher or the learner. A mixed-initiative approach potentially can retain the best of both forms of education. It means that the various agents can take the lead or initiative in an interaction at appropriate times, in contrast to tutor-guided learning or student discovery-based learning.

I am interested in how scenario-based training and learning works, and what is the most effective way to support learners in such a context. I seek to establish a number of “elements” or “influences” involved in supporting mixed-initiative scenario-based training and relate these to principles of game-based learning and experience gained in that field.

A number of threads have been brought together in this work:

- to study the cognitive psychological foundations for socially situated learning;
- to identify effective learning methods relevant to mixed-initiative interaction between agents;
- to describe the relationship between cognitive psychological activity models and an AI research-informed conceptual model of activity;
- to provide a methodology for how the concepts identified could be utilised in a training-orientated “I-Zone” supported by intelligent systems technology – a virtual space for intelligent scenario-based learning; and
- to create, document and demonstrate a resource base for experimentation and potential re-use on projects in this area.

This dissertation takes the form of providing a conceptualisation, describing a methodology and providing a realisation of a virtual space to support scenario-based training in a community context. This is a theoretical and design project, and not one which culminates in the collection and analysis of empirical evidence.

The work has made available a coherent set of resources and related readings which could form the basis for future collaborative research and student projects. It provides useful inputs to my continuing intelligent systems and collaboration focused research on “Virtual Spaces for Intelligent Interaction” with an emphasis on mixed-initiative support to scenario-based training for emergency responders.

SECTION 1 – INTRODUCTION

I approach this study as a researcher supporting communities who engage in training and experimentation in fields such as emergency response. The people involved make use of role play in simulations with detailed scenarios. Based on previous practical and design-led experience in the provision of collaboration tools for them, I would like to understand more from educational research about scenario-driven training and learning and how it can be most effective.

Such training can have a narrower objective as compared to broader educational aims, as it may be centred on the learning and generalisation of operational techniques and situation specific knowledge required by the target community. Reality provides the context and the constraints under which a trainee can learn processes and make sense of the choices available. Trainees need to have enough knowledge to make sense of the current situation, understand what can happen, and mentally project forward what the results might be of decisions they make or activities they perform. This kind of mental projection exercises the knowledge they already have, and forces them to address situations they may not have encountered before. It introduces options unfamiliar to the trainee which have to be confronted, and pros and cons have to be argued in a shared social setting. That is often what a well-designed training scenario seeks to introduce to a trainee. My aim is to understand ways in which an effective and engaging community-orientated scenario-based training exercise can be designed and guided to be most effective for the learners involved. If there are insights that can be taken back into education from the wealth of experience in the military and civil scenario-based training communities that would be a valuable effect too.

The use of simulations and gaming in a social setting for learning is not a new trend. Plato (360 B.C.) shows an early advocacy of experiential learning through games and observational experiences. Erikson's (1977, chapter 1, p.17) “Toys and Reasons” summarises this well:

> “Of all the formulations of play, the briefest and the best is to be found in Plato's Laws. He sees the model of true playfulness in the need of all young creatures, animal and human, to leap. To truly leap, you must learn how to use the ground as a springboard, and how to land resiliently and safely. It means to test the leeway allowed by given limits; to outdo and yet not escape gravity.”

Much more recently, Alex Games (2011), Education Design Director at Microsoft Studios, in his work on using games for augmented reality and embodied learning in the classroom, comments:

> “Nearly three decades of scientific research in games and learning have shown evidence that game play can help players develop a systemic understanding of world phenomena, creativity and strategic problem solving skills. In the sequence of solving complex problems, the act of playing engages players cognitively and emotionally, and assesses knowledge where it is highly relevant to those problems' solution”.

I want to relate a number of threads of work in this dissertation, and a flow diagram of some of the concepts I will discuss may be helpful to maintain a sense of direction from my overall objectives down through theory, concepts, representation and technology, through a realisation or embodiment of the ideas, and on to its application to my area of interest.

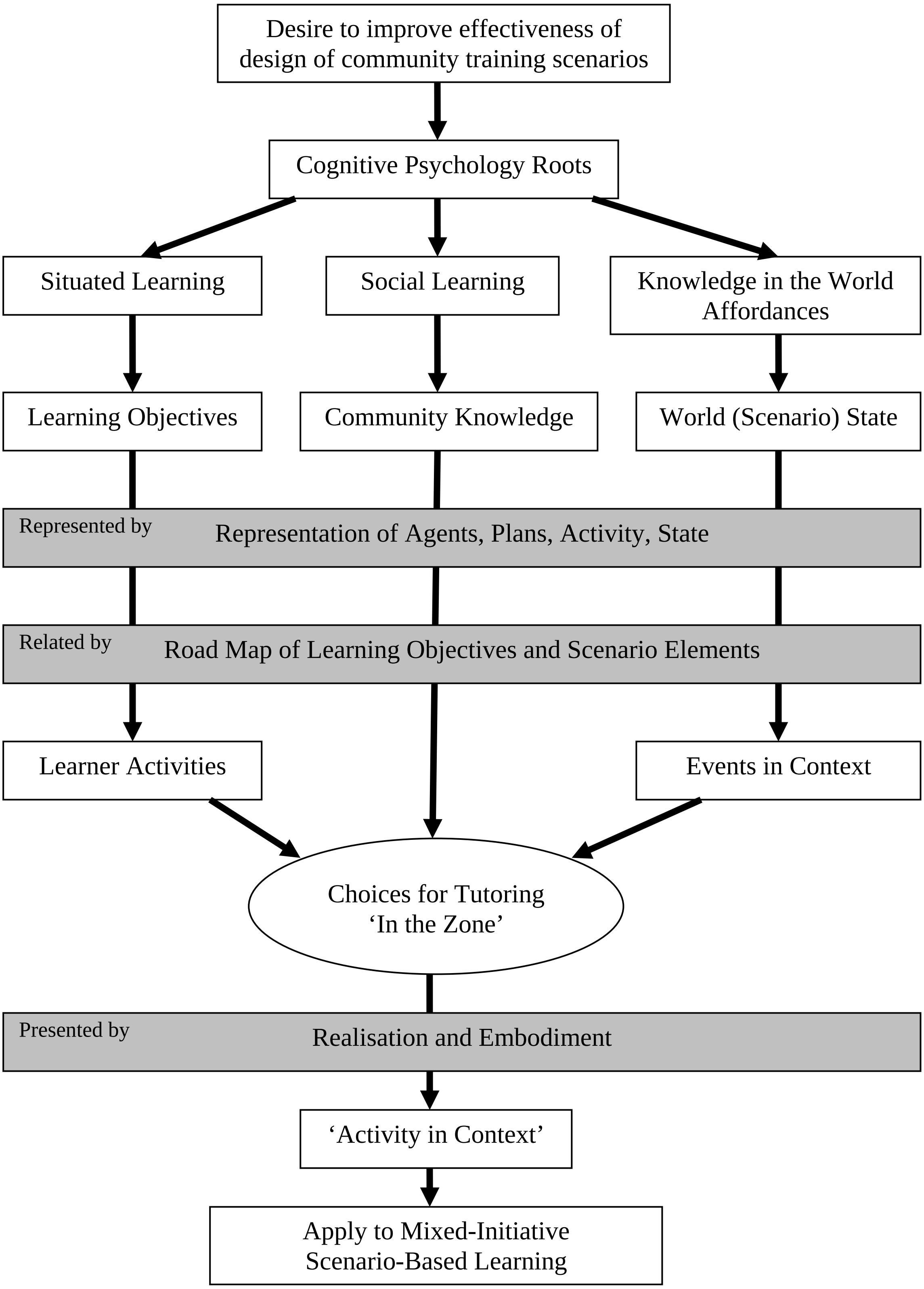

Figure 1.1: Flow Diagram of Concepts explored in the Dissertation

This dissertation takes the form of providing a conceptualisation, describing a methodology and providing a realisation of a virtual space to support scenario-based training in a community context. This is a theoretical and design project, and not one which culminates in the collection and analysis of empirical evidence. My aim is to use previous practical and design-led experience alongside newly acquired insights from this study to describe a methodology or approach to support the generation of scenario-based training episodes that are context-sensitive to the receptiveness of a student to learn effectively.

The area of study involves a very broad field with a vast existing literature in cognitive psychology, pedagogy and artificial intelligence. The work includes a form of "configurative" review as defined in an overview of research methodologies by Gough et al. (2012) and especially the sub-categories of a "critical interpretative synthesis" (i.e., what theories can be generated from the conceptual literature?) and a "meta narrative review" (i.e., how to understand the development of research on an issue within and across different research traditions?).

Hence, the dissertation begins with a description of educational cognitive psychology work relevant to situated learning for members of communities engaged in knowledge-based activities. There follows an overview of work from artificial intelligence on intelligent tutoring systems. I then show that the information relevant to a training situation can be *represented* via a simple conceptual model of activity and agent interactions that has been developed in AI research on flexible planning in dynamic environments. This opens up the potential use of automated AI planning technologies to generate and adapt learning sequences and tutorial episodes. I describe a method to *relate* overall learning objectives to specific activities via a road map which can help when selecting or generating suitable options for activity in a mixed-initiative training situation. The core area of this study, shown as an ellipse in the flow diagram, is a focus on the *choices* of the appropriate and timely scenario state to set up and the scenario events to inject in order to solicit learner activities to achieve the intended learning objectives, and do that in an engaging way by keeping learners in an effective learning "zone".

The methodology can be summarised as:

- **constrain** the world situation and the activities which are possible;
- **select or generate** relevant tasks and events to **inject** into the situation to keep learners 'in the zone' for effective learning; and
- **induce** appropriate learner 'activity in context'.

This study has explored a virtual world realisation of the learning situation in the form of an "I-Zone" with in-world tutors or teaching assistants which can provide an immersive virtual environment to *present* the learning context to those being trained and to set appropriate and challenging objectives. This is grounded in the design of real world operations centres or training facilities used by emergency responders and the expert trainers involved in those.

SECTION 2 – RELEVANT EDUCATIONAL PSYCHOLOGY

This section describes work in cognitive psychology relevant to effective learning and community orientated scenario-based training. Although in some cases the work is described in the context of learning in young children, many of the same principles apply to learning with more mature participants.

2.1 Learning by Doing

Piaget (1954) observed that children learn about the world by exploring it and playing with it. He claimed that an environment that is set up to encourage appropriate discovery can accelerate learning. He identified a number of developmental stages in a child's capabilities for thinking and doing in an approach termed "constructivism". Papert (1980) worked with Piaget prior to co-founding the MIT AI Laboratory and took the ideas further by encouraging learners to construct items and interact with them to reinforce their understanding in a theory of learning called "constructionism" (Ackermann, 2001).

Vygotsky (1934) emphasised the importance for learning of experience through social interaction with the environment. Vygotsky described the "Zone of Proximal Development" (ZPD) in which he believed really valuable learning takes place. This is a situation where a learner is just beyond their comfort zone of existing competence and where, with suitable training and perhaps a constrained context and set of choices during their social interaction with others, they can acquire new knowledge or refine their existing knowledge through their grounded experiences.

2.2 Situated Learning

Gee (2008) contrasts the work on thought and learning as symbolic reasoning advocated by some in the AI community, for example, by Vera and Simon (1993), with the "Learning Sciences" notion of cognition and learning as "interaction in the social and material world" advocated, for example, by Greeno and Moore (1993). Gee notes:

> "Earlier learning theory argued that the mind works like a calculating device, something like a digital computer. On this view, humans think and learn by manipulating abstract symbols via logic-like rules. Newer work, however, argues that people primarily think and learn through experiences they have had."

Gee's work is focused on experiences of users playing video games to derive a number of learning principles to inform effective learning. In a talk in 2012 (Gee, 2012) he notes that in much school learning "we have handed learners the manuals without the game", i.e., there are processes and definitions, but they are not grounded in the situation and world they apply to. Scenario-based training provides the "game" or situation in which the processes to be learned are meant to be applied.

There are a number of studies (e.g., Barsalou, 1999a; 1999b) which indicate that people run a simulation in their heads of actions to be carried out in the situation they are addressing and that the imagery involved is essentially pictorial in nature.

> “... comprehension is grounded in perceptual simulations that prepare agents for situated action” (Barsalou, 1999a)

Scenario-based training allows the learner to gain experience of processes in a controlled and perhaps less dangerous setting than real life. It allows the experiences to be assimilated and a perceptual picture built of the consequence of performing activities in that world. This later allows more effective replay of those experiences and subsequent adjustment of them in new situations.

2.3 Social Learning

Lave and Wenger (1991) continue the approach of Vygotsky and describe learning as a situated process in the context of social engagement with “communities of practice” – groups who share knowledge and methods for some area of expertise. The earlier Social Learning Theory of Bandura (1977) is based on the premise that people learn through observing others performing activity. Gee (2005) explores interactions between members of a community in an “Affinity Space” (also called an “Affinity Group” in Gee, 2007) where the members are bonded by shared objectives, processes and experiences rather than just membership of a community.

Wenger (1998) in his further study of communities of practice notes the benefit of learning taking place “in the context of our lived experience of participation in the world”, and believes that learning is fundamentally social in nature. He identified a number of components (shown in figure 2.1) of a theory of social learning which have been very widely adopted.

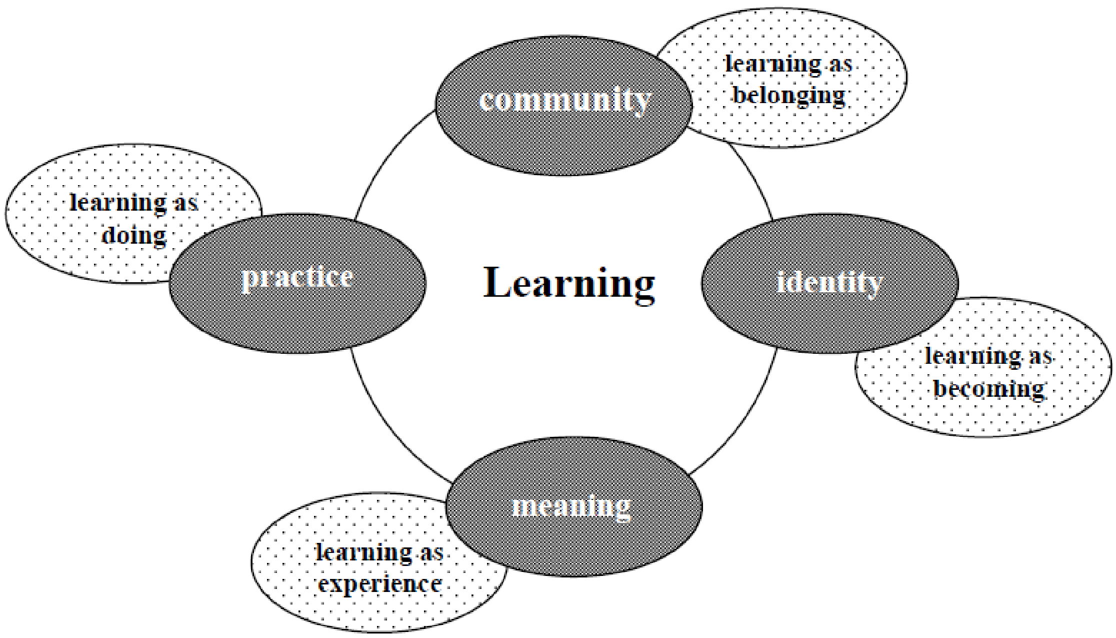

Figure 2.1: Components of a Social Theory of Learning from Wenger (1998, Figure 15.1)

Rheingold (1993) also shows examples of learning being encouraged through exploring worlds and well-written scenarios in them. In his research he has described a number of simulated exercises involving communities of practice which are designed to reinforce learning and which proved highly successful.

Steinkuehler (2004) states:

> "Through participation in a community of practice, an individual comes to understand the world (and themselves) from the perspective of that community. Here, semantic interpretation is taken as part of what people do in the lived-in world; it arises through interaction with social and material resources in the context of a community with its own participant structures, values, and goals (Greeno and Moore, 1993). For example, an individual becomes attuned to a particular object's constraints and affordances through the regular pattern of interaction that individual has with it, but this regular pattern of interaction is shaped by the individual's membership in a particular community for whom the object has meaning, usefulness, and relevance for a given task with a given (individual or collective) goal."

Brown and Campione (1994) describe learning in a "Community of Learners" within a "Zone" of joint activities – named after the work by Vygotsky (1934) on the Zone of Proximal Development. Collaboration between people and interaction with artifacts in the environment, combined with good "scaffold" processes can provide a template or structure for their assimilation (as described by Wood, Bruner and Ross, 1976) and allow a learner to achieve a new level of accomplishment. In the context of mixed-initiative learning, the tutor can establish an effective framework and suitable guidance to support the initiative which they seek to encourage from the learner.

2.4 Communities, Action and Change

Kurt Lewin (1946) was an early investigator of problem-solving activity in a community of practice. He describes "Action Research" as:

> "… research on the conditions and effects of various forms of social action and research leading to social action that uses a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action".

He was particularly interested in the way in which participants had to be made to "unfreeze" their current processes and models of the environment in order to be open to new approaches or "change" before they then were able to "freeze" and make more automatic the new methods adopted and be able to apply them effectively and routinely in the changed circumstances. The unfreezing step usually requires some form of intervention such as a restructuring, or the creation of some form of real or perceived crisis. Lewin's "unfreeze – change – freeze" model is still the underlying basis of many strategies for managing change in organisations.

2.5 The Power of Stories

A good narrative or story is a very powerful cultural mechanism to promote effective learning (see Schank and Abelson, 1977; Psychology Today, 2011).

For many years scientists involved in cognitive studies have sought to employ stories as an organizing method for human memory and recall. Stories have been a focus for understanding the world, for representing potential activity in the world and for communicating intentions and plans between people. Schank (1977) with his idea of "Scripts" shows us that we often have some quite fixed story-boards or processes in mind when we are engaged in activity, and we adapt these to the situations we encounter, situations such as a visit to a restaurant. We expect certain things to happen at certain times and in noisy environments or in some unfamiliar foreign restaurants these scripts can be helpful in understanding the interactions we will have. So much so that an amusing experience can result when encountering a really different culture or eating at a restaurant that does not follow our usual script. We can also "debug" those scripts when we come across new situations and adapt them for future more general uses. It is the power of those scripts and how we assimilate them that lets us cope better in new situations. Scripts and story outlines are also a focus for making sense of what we observe in the world: we try to fit what we observe into what makes sense in terms of our "scripts" for the situation.

A study of the power of stories along with further resources on this topic is available in Tate (2011b).

2.6 Intrinsic Motivation and Learning Principles in Games

Tom Malone's studies of the intrinsic motivation which can apply in the use of games for educational uses (Malone, 1981) give us some indication of how to design engaging experiences in simulation-orientated environments. Educators have observed that learners can have a number of intrinsic motivational factors when engaged in a game or simulation if it provides a challenge, stimulates curiosity, gives a sense of control and even involves a fantasy element in the storyline. Additional factors were observed in some scenario-based social learning environments such as identity presentation, social relationships, helping others, immersion and creativity (Barab et al., 2005). They discuss their approach as exercising three aspects – learning, helping and playing – and see this as a way to encourage the natural behaviour of children to engage in play and to learn through that play (as described by Piaget, 1954). In a more mature context we might see this as "Learning through Experience" in an immersive story-based scenario.

Gee (2007) identifies 36 learning principles that could be utilised from effective and engaging video-game playing experiences to be used more broadly in scenario-based training. Gee (2008) continues to develop this idea and states that:

> "... good video games recruit good learning and that a game's design is inherently connected to designing good learning for players..."

Gee identifies the learning opportunities afforded by achievable challenges that are selectable or adjustable by the game, environment or tutor to stretch a learner’s skill and retain interest, but not to be impossible to perform.

2.7 5E Instructional Model

Due to my intrinsic interest in the subject area, as a theme in a study of game-based learning on the MSc in e-Learning in 2012 I explored a wide range of space-themed games, and especially ones created by the major space agencies (Tate, 2012). Some of NASA's educational programmes explicitly adopt a constructivist learning approach called the “5E instructional model” (NASA, 2012) to help learners build their own understanding from experiences and new ideas. The 5Es represent five stages of a sequence for teaching and learning: Engage, Explore, Explain, Extend (or Elaborate), and Evaluate. The 5Es model was originally developed for the US Biological Science Curriculum Study in the 1980s and has been refined since (Bybee, 2009). The creators of the 5E model cite Piaget (1954) amongst its prime influences. As we will see later (section 5.5), a number of other approaches in both educational contexts and practical decision making environments adopt such a developmental cycle.

I believe that the NASA 5Es approach could be a useful guiding framework for the stages of support given by an automated agent in a learning situation. The overarching stages involved could provide a guide to the activities engaged in by students, a tutor and an AI-driven classroom assistant, and hence suggest an overall process which might be used to select appropriate events or activities to take the initiative in a mixed-initiative training situation.

SECTION 3 – AI IN LEARNING SYSTEMS

Computer Aided Instruction (CAI) has been employed to support the presentation of materials to learners for almost as long as computers have been available. Artificial Intelligence (AI) researchers have been interested in applications to teaching and learning for almost as long – leading to the creation of a number of Intelligent Tutoring Systems (ITS). A history of the use of AI techniques in learning and teaching is provided by O'Shea and Self (1983). A later introduction for the non-specialist to the themes in intelligent teaching systems and AI applications to education was provided by Nwana (1990) who also included a comprehensive list of intelligent tutoring systems and environments.

3.1 Monitored, Mixed-Initiative and Guided Discovery Learning

Nwana (1990) shows that ITS can be classified into the type of interaction they support between learner and tutor:

> "… the tutoring in existing ITS can be classified along a spectrum ranging from systems that *monitor* the student's every activity very closely, adapting their actions to the student's responses but never relinquishing control, to *guided discovery* learning systems where the student has almost full control of the activity, and the only way the system can direct the course of action is by modifying the environment. In the middle are *mixed-initiative* systems where the control is shared by the student and the system as they exchange questions and answers."

My interest and focus is on educational techniques that can apply in mixed-initiative scenario-based training.

3.2 Intelligent Tutoring Systems and AI in Education

A book by Sleeman and Brown (1982) on ITS is a classic text and brings together separate papers which describe work on the key systems and by the key researchers of the day. These early systems include SCHOLAR, SOPHIE, GUIDON, DEBUGGY and WEST. They sought to incorporate student models describing the strengths and weaknesses of students' achievements against the target learning outcomes, and provided feedback such that the materials presented to the students could be adapted to their level of understanding of previous materials and not to cause them to become too frustrated by either too simple or too complex a level of material.

Borwarnginn (2012) in her initial PhD studies has provided an insightful overview of the early literature which nicely summarises the early work on ITS. She says:

> "Sleeman and Brown's book … stated the original goal of ITS was 'to extend the domain of applicability, the power, and the accuracy, of adaptive systems'. ITS intended to optimise the long-term learning gains such as evaluating the results and determining the level of difficulty of the next exercise. The research focused on *learning-by-doing* which means 'transforming factual knowledge into experiential knowledge'. These systems attempted to combine the problem-solving experience and motivating power of discovery learning with the effective

> guidance of tutorial interactions. They specified the early ITS as a form of computer-based 1) problem-solving monitor, 2) coach, 3) laboratory instructor or 4) consultant."

Wenger (1987) for his own PhD studies provided a uniform overview of the early work on intelligent systems for tutoring, reviewing the key systems such as SCHOLAR, GUIDON, the various SOPHIE systems and the simulation-based STEAMER by comparing their features in a common terminological framework. He also observed (Wenger, 1987, p. 21) that there were varying degrees of control over the learning in the ITS systems which he classified as strict monitoring, mixed-initiative and coaching. Even the very earliest ITS systems such as SCHOLAR and the original SOPHIE sought to provide inputs to guide learning in a mixed-initiative way, a term first used by Carnonnell (1970) in the description of SCHOLAR, by tracking student performance on a "semantic network" of concepts to be learned.

3.3 Computer Supported Collaborative Learning

The first two decades of work on intelligent tutoring systems was mostly focused on one-to-one teaching to support a single student working alone. But more recent work has involved peer-to-peer teaching and the social framework in which most learning takes place. This is often called Computer Supported Collaborative Learning (CSCL). One group working in this area motivates their interest as follows:

> "Educational researchers and practitioners have long believed that learning is heavily influenced by the motivational consequences of social interactions inside and outside the classroom." [from LRDC web site at http://www.lrdc.pitt.edu/]

The ITS research agenda is predicated on the Piagetian constructivist model of learning (Piaget, 1954), with the CSCL work calling upon the "social constructivist" notions coming from Vygotsky (1934).

An excellent example of the CSCL approach is described in Soller (2001) which has strongly influenced my own research agenda for the current work. She has studied the use of Personal Learning Assistants (PaLs) which can employ a limited and structured grammar of inter-agent speech acts and performatives relevant to learning in a social community involving peer-to-peer and student-to-tutor activities. They can provide a target set of "Learner Activities" for dealing with events in a social and situated learning setting – something I will return to in some detail later in Section 6.

Research themes appearing in relevant conferences over the last decade in the use of artificial intelligence in educational systems confirm a broad interest in social and community dimensions in learning. The themes have been summarised in a report for the AI in Education (AIED) community by Underwood and Luckin (2011) as Agents, Collaborative Learning, Dialogue Systems, Narrative and Games, Pedagogic Strategies, Authoring Tools, Evaluation, Learner Modelling, Hypermedia & Web-based systems, and Affect & Motivation. There have been some preliminary efforts to define an emerging pedagogy for community knowledge construction in on-line social networks and virtual worlds (Dawley, 2009).

3.4 Learning by Exploring and Construction

One influence of AI researchers has been in using "constructionist" principles in educational technology, themselves a refinement of Piaget's approach. The LOGO system (Papert, 1980) provides an exploratory learning environment and is a foundational example of this approach. By situating building activity in a world in which a "turtle" can move and draw lines described by a learner, the LOGO environment is able to give immediate feedback and encourage experimentation and refinement of the learner's design – see figure 3.1. LOGO's "learning by programming" approach had an influence on many subsequent "learning by building" and "learning by design" environments, whether in software simulations or even in the range of LEGO "Mindstorms" robotic construction kits.

Figure 3.1: LOGO Turtle Edinburgh Prototype from 1979 –
On Display in the Informatics Forum at the University of Edinburgh

3.5 Learning by Debugging

A number of approaches to the use of AI in tutoring involve "debugging" the process or model a student has of some subject matter under the guidance of a tutor. Several of these systems are based on a representation of plans or scripts (Schank and Abselson, 1977) which may not be correctly applied by the learner. For example, the DEBUGGY system (Burton, 1982) seeks to diagnose and correct specific procedural errors in a learner performing arithmetic operations.

Close to my own interests in the field of intelligent planning (Tate, 2000), NOAH (Sacerdoti, 1977) is an AI planning system which could generate repair plans for mechanical equipment and interact with a student repairing the equipment. The student could be guided to unravel faulty steps, and understand the fault in their understanding, prior to trying again to get back on track with a valid repair approach.

3.6 Computer-Based Pedagogical Agents

A number of people have studied computer-driven pedagogical agents in classroom settings especially where mixed-initiative approaches to learning are being taken (Lester et al., 1999) and where animated and lifelike learning support agents are employed (Johnson et al, 2000).

A number of papers presented at the Researching Learning in Virtual Environments International Conference (ReLIVE, 2008) on 20-21 November 2008 at The Open University explored pedagogical agents in virtual worlds, a topic very relevant to my own study here. This conference was organised to bring together researchers in a number of disciplines who were interested in educational uses of virtual worlds. So not surprisingly there are many relevant papers and indications of further work in this collection of papers.

Clinton (2008) explored the possibility of using Non-Player Characters (NPCs) in a virtual world classroom context and ways in which their interactions can be structured to link to virtual learning environment modules involved with tasks and activities. Linking an AI-driven classroom assistant to a Virtual Learning Environment such as Moodle via the SLoodle module (Livingstone and Kemp, 2008) is close to my own aims, so these works and contact with the authors have been useful in the current study.

Camilleri and Montebello (2008) created a "Second Life Assistant in a Virtual Environment" (SLAVE) based on an NPC and ALICE chatbot technology (Pandorabots, 2012) and studied its use in a range of educational projects with students at the University of Malta. Their analysis of the educational pros and cons provides a useful and very specific instance of technology similar to that explored in the current study and described in a later section. NPC-based tutors have also been found to be productive by Jeffery (2008).

Going further, Minocha and Tingle (2008) linked virtual worlds and a web-based virtual learning environment to provide a social dimension to the learning they sought to support via a NPC tutor. This is similar to my own work on combining web 2.0 technologies with virtual worlds in the Open Virtual Collaboration Environment (Tate et al., 2010b).

But a cautionary note is struck by Scantlebury et al (2008) who set out to create an AI-based librarian avatar ("Callimachus") for a library area in the Open University welcome zone in Second Life™ (Linden Labs, 2012). Although many good ideas were generated for the potential functionality, the realism of creating an actual implementation and the limitations of the available budget meant that relatively little could be achieved in practice.

There is a wealth of literature in the area of using AI in NPCs and other facets of games. A number of these games have been directed at educational activities. A nice summary along with some history of the development of AI in games is available in a project from the University of Rochester (Wexler, 2002). Further resources are accessible on-line at the AI Game Programmers Guild web site at http://gameai.com.

SECTION 4 – NOTIONS OF ACTIVITY

I am seeking to develop a coherent approach to link mixed-initiative scenario-based learning with the many concepts from educational psychology and advanced educational technology work discussed in the previous sections. There is an interesting overlap between work in these areas and the work I have been engaged with in artificial intelligence on rich plan representations, agent technology and task-support systems, especially for collaborative work involving significant community knowledge of process and context.

My approach draws on my work on representation and reasoning about plans and activity (Tate, 2000) and especially on my recent work on I-Rooms (Tate et al., 2010a; Tate, 2011a) to support collaboration in virtual worlds. One key contribution is to provide a simple, abstract and extendable representation of collaborative activity into which the cognitive psychological insights can be fitted. If this is done, some level of automated plan and agent activity analysis, planning and activity execution support can be provided.

4.1 Activity in Context

I am exploring the notion of "Activity in Context" in this study. Context-specific activity and planning is a core concept I have used in a lot of my previous work and which I term "knowledge-based planning and activity management". See http://www.aiai.ed.ac.uk/project/plan/. The context defines a strong set of constraints on what actions from a potentially vast set are possible and hence need to be considered. My planning systems aim to present to a human planner the limited actions which are possible in a context or on an object and show if they can be executed now (the environmental context already admits them) or if they still need some constraints to be met to make them applicable. This context sensitivity can radically reduce search. There are lessons to be learned from this approach which could usefully be applied more generally in education, especially in a situated learning context.

Marvin Minsky in his book "The Society of Mind" states a principle of knowledge-based problem solving and notes that:

> "the most efficient way to solve a problem is to already know how to solve it. Then one can avoid search entirely" (Minsky, 1985, p. 74).

Studies of human problem-solving in stressful and dangerous environments show that people often use many constraints from the environment or their training to leap to solutions and sometimes the practitioners say "But I don't plan, I just know what to do" (Klein, 1977). They perceive their environment in a way that naturally constrains what can and cannot be done. Sometimes delaying a decision can allow more constraints to become apparent such that potential activity choice is reduced. In an exchange with Gary Klein, I have compared my own approach to knowledge-based planning and constrained activity management with Klein's own studies (Tate, 2000, Appendix) and there are many similarities.

As noted before, Gee (2003) analyses video games and identifies many learning principles which make them powerful bases for learning (his appendix is a short cut to all 36 which are gradually exposed through the book). Many of these principles rely on the grounding offered by a real-world scenario or constrained world in which the action takes place. The ability for the player/learner to probe ("poke") the world through the actions they take, often when several are possible, to get feedback and then to reformulate their hypotheses about the situation all serve to stimulate learning.

4.2 Plans, Activities, Constraints and Agents

The terminology of plans, activities, constraints and agents is used throughout cognitive psychology and learning-observation texts (e.g., Norman, 2002) and plans are used for communication (Agre and Chapman, 1989) as well as action. Suchman (2007, p. 13) suggests plans should be seen not as precursors to action but as "cultural resources" to describe projections of future activity. My own research in plan representation uses ontological entities for shared understanding and communication between agents, as well as providing a specification for performing activities. It employs a mixed-initiative multi-agent model of "mutually constraining the space of behaviour" which is compatible with relevant psychology approaches.

4.3 Constrained Activity – Affordances

Scenarios leverage our knowledge of the real world. They can powerfully draw on the natural "knowledge in the world" (Norman, 2002), that is, the natural understanding of the constraints under which activity can take place in a real setting. Objects in the world constrain how an agent perceives it can interact with them.

There is a clear overlap for descriptions of contextualised and constrained (by the world) activity to the use of the term "affordance" – how the objects in the world constrain and limit the choices open, often to a single natural choice. The primary reference to affordances in perception is Gibson (1979), but Gibson (1977) also covers the topic. Norman (2002) notes:

> "Affordances suggest the range of possibilities, constraints limit the number of alternatives. The thoughtful use of affordances and constraints together in design lets a user determine readily the proper course of action, even in a novel situation." (Norman, 2002, p. 82).

A more recent essay by Norman (2011) provides a good summary of the Gibson origins of the term and its development. Norman uses "Perceived Affordance" as his preferred term for clarification, and he further describes its more recent use in user interface design.

As mentioned previously, Klein (1977) recorded emergency responders as stating "But I don't plan, I just know what to do" which reflects the richness of the knowledge in the world which they respond to. "Affordances" provide knowledge in the form of easily understood limitations on behaviour. I believe that can be used by a tutor in mixed-initiative scenario-based training and learning situations. The tutor can set up a suitable environment and tasks to limit choices and guide learning. We wish to take people to the edge of their understanding and then keep modifying the environment and objects in it to limit the learners' scope for activity to maintain them in a high-value targeted learning situation.

4.4 Constraints and Transfer in Learning

There is work on "transfer" in learning (e.g., Bransford and Schwartz, 1999) which shows the value of constraining the environment especially in new contexts so that the choices of activity are limited and within the scope of previous experience or learning to enable more effective assimilation of new or adapted processes.

> "... people actively adapt their environments to suit their needs. People, for example, will modify the positions of utensils and dry goods when they go to a new kitchen. This new kitchen does not have to be exactly like their old one (e.g., the kitchen might have different numbers of drawers). People accommodate their old schemes to the new kitchen, and they adapt the kitchen to their old schemes and "personal" strengths. Actively controlling the environment seems especially important with regards to future learning, ...
>
> An important way that learners interact with their environments is by creating situations that allow them to "bump up against the world" in order to test their thinking. If things don't work, effective learners revise." (Bransford and Schwartz, 1999, p. 24).

Suitable constraints can be introduced into a scenario by a tutor in a mixed-initiative learning context to limit the activity choices possible and help learners most effectively explore the space of possibilities which can stretch and help generalise their learning.

SECTION 5 – A FRAMEWORK USING I-X TECHNOLOGY AND THE <I-N-C-A> ONTOLOGY

In this work I am seeking to draw on the I-X – "Intelligent Things" – research programme. This involves a number of different aspects intended to create a conceptually simple approach to allow humans and computer systems to cooperate in tasks such as planning and collaborative design – specifically the creation or modification by one or more agents of some product or products such as documents, plans, designs or physical entities. I.e., it supports mixed-initiative "synthesis" tasks.

The I-X research draws on earlier AI planning work on Nonlin (Tate, 1977), O-Plan (Currie and Tate, 1991; Tate, 1995; Tate et. al., 1998; Tate et. al., 2000b, Levine et. al. 2000), Optimum-AIV (Aarup, 1994), <I-N-OVA> (Tate, 1996; 2000a) and the Enterprise Project (Fraser and Tate, 1995; Uschold, et. al., 1998; Stader, 1996) but seeks to make the framework generic and to clarify terminology, simplify the approach taken, and increase re-usability, extendibility and applicability of the core ideas.

There are three aspects of the I-X technology research programme relevant to the current study. The first is the "<I-N-C-A>" abstract model of plans, standard operating procedures or processes, and activity descriptions based on the concept that these can be described as a set of "constraints on activity". Secondly, the I-X approach for enacting mixed-initiative multi-agent interaction and collaboration. And finally, use of the approach in the creation of a virtual space for intelligent interaction – the "I-Room" – on which an "I-Zone" for intelligent scenario-based training explored in this study is based.

5.1 <I-N-C-A> – Issues, Nodes, Constraints and Annotations

My work on rich plan representations has been refined in many exchanges with scientists and practitioners working in a wide range of fields where plans are used. This has also brought me into contact with those concerned with the exchange of plan and activity related information, including in the standards community. As a result of these exchanges, a core plan ontology (Tate, 1996a, Tate, 1996b) has been developed into an abstract conceptualisation termed <I-N-C-A> (Issues – Nodes – Constraints – Annotations) (Tate, 2003), expressed as a "set of constraint on behaviour". This is the conceptual model that underpins the I-X mixed-initiative approach, and provides a flexible, extendable and intelligible representation of the processes and process products in I-X. It is well suited to communication between human and system agents engaged in a mixed-initiative fashion on some common complex task, each possibly taking the initiative over which parts they can handle at various stages.

The representation of plans involves:

- Issues to be addressed by cognitive processes
- Activities (termed Nodes) to perform after deliberation
- Constraints to respect – using knowledge from the world and experience
- Annotations to record decision rationale and status

This abstraction has been used as a key input to work on a range of widely applied shared plan representations including the DARPA Shared Planning and Activity Representation (Tate, 1999), the MIT Process Handbook and its Process Interchange Format (PIF) (Lee et al., 1998) which itself became the core of the NIST Process Specification Language (PSL) (Knutilla et al., 1998). PSL has now been published as ISO Standard 18629.

<I-N-C-A> models are intended to support a number of different uses:

- for automatic and mixed-initiative generation and manipulation of plans and other synthesised artifacts and to act as an ontology to underpin such use;
- as a common basis for human and system communication about plans and other synthesised artifacts;
- as a target for principled and reliable acquisition of knowledge about synthesised artifacts such as plans, process models and process product information; and
- to support formal reasoning about plans and other synthesised artifacts.

These cover both formal and practical requirements and allows for understanding by the people involved and automated processing by computer-based planning systems.

In this dissertation I have related work on plan ontologies in AI to the psychology of activity, and its use in education and personal development. That the terminology of plans, activity, agents etc. should be similar to that used in the social sciences and educational psychology literature is unsurprising since one field of AI is termed "Cognitive Sciences". But what is perhaps more surprising is the very close match of the terminology used by educational psychologists with the fundamental ontological constructs that are the basis for the technically derived standards described above and which have been adopted over a long period in my own work on planning and plan representation. These have come from quite a different perspective and have been developed in work with a very different community.

I am particularly intrigued by a statement from Norman (2002, p 84) that there are:

> "…four different classes of constraints – physical, semantic, cultural, and logical. These classes are apparently universal, appearing in a wide variety of situations, and sufficient."

I am always seeking additional well-justified sub-categories of <I-N-C-A> elements, and have absorbed several from other disciplines during my professional research. This insight could be a valuable addition to my own approach to constrained activity modelling, to allow for elements that typically do occur in the sort of training I engage in (where policy and cultural constraints are commonplace) and lead to insights that will be directly applicable in my work.

5.2 I-X Mixed-Initiative Approach

The I-X approach involves the use of shared models for task-directed cooperation between human and computer agents who are jointly exploring (via some predefined or dynamically created process) a range of alternative options for the synthesis of one or more artifacts or products which can be physical products, documents or even plans.

As an example, a process represented in <I-N-C-A> might describe a car manufacturing operation, with its nodes being descriptions of a set of manufacturing and assembly activities with temporal and resource constraints on the operations and tools being used. Whereas a product in this same domain described in <I-N-C-A> would have its nodes as descriptions of the set of car parts being brought together in spatial relationships to one another. In a planning process, the product can be a plan or document describing a plan.

A number of psychologists have described models showing the interconnectedness of performing activity and producing artifacts. This is sometimes called the "task-artifact cycle" (Carroll et al., 1991; Carroll and Rosson, 1992).

The model of mixed-initiative synthesis taken in I-X is to allow for human and system agents to work in harmony to "mutually constrain" the set of processes or products of interest by each adding constraints on the space of possible behaviours or products. Human and system agents are not seen as at a higher level or "in charge" as far as the I-X architecture is concerned. However, orderings and priorities can be applied to impose specific styles of initiative within the system. One extreme can be a human-driven approach followed by computer agents "filling in" the details, or the opposite extreme of a fully automatic computer-driven approach (with perhaps occasional appeals to a human agent to take designated decisions). Tate (1994) describes how the human and computer agents in some practical situations could be characterised as working together in a mixed-initiative fashion via the following roles:

- humans add, discuss or answer questions posed as "issues";
- computer agents find and show options for potential "nodes" (e.g., activities);
- humans decide to add specific new "nodes" (e.g., activities);
- computer agents manage and propose consistent solutions for the set of detailed "constraints"; and
- both humans and computer components add "annotations" to record their decision rationale.

The underlying <I-N-C-A> representation supports plan use by both the people involved and by computer-based planning systems.

5.3 Issue Handling

A feature of the I-X approach is that issues are explicitly represented and used to drive problem-solving. Issues are expressed as a set of questions to be addressed for the target artifact (plan, process or product) represented by an <I-N-C-A> specification. Issues effectively are "pending" constraints on the artifact but ones which cannot yet be made explicit without further decision making. Issues are stated as one of seven types of generic questions that arise in collaborative problem-solving and issue-based design (Conklin, 2005). The questions can lead to the generation of options, which in turn can drive collaborative discussions on the relative pros and cons of selecting each of the options, and allow for evaluation criteria to be sought and applied to these options. This approach to problem-solving is sometimes referred to as the “Questions – Options – Criteria” (QOC) method. Such reasoning is captured in I-X systems and in the annotations elements of <I-N-C-A> so that problem-solving and design rationale is maintained for later use during adaptive execution of plans or refinement of designs during manufacture or in product usage (Polyak and Tate, 1998). The issue-handling approach is similar to the “brainstorming” argumentation support techniques used in concept mapping tools such as Compendium (Selvin et. al. 2001). The interaction between student and tutor in a mixed-initiative fashion may be supported by the exchange of issues or questions, option generation and discussion (answers), and selection of a course of action through critical evaluation using appropriate criteria.

Work in some Intelligent Tutoring Systems has used the idea of an agenda of issues or tasks to drive student interaction with a tutor or with earning resources and to maintain flexibility in the dialogues involved. E.g., WEST (Burton and Brown, 1982) employs an issue tracing mechanism to identify which features the learner has mastered and to guide when it is worth the tutor taking the initiative to assist the student.

5.4 I-Room: Scope and Concepts for Effective Collaboration

I-X technology and the underlying <I-N-C-A> ontology have been used to create a range of virtual worlds-based I-Rooms for collaboration by distributed teams in a range of application areas (Tate et al., 2010). Truly distributed mixed initiative collaboration and task support is the focus of the I-Room, allowing for the following:

- situation monitoring
- sense-making
- analysis and simulation
- planning and option generation
- option analysis
- briefing
- decision making
- responsive enactment

This same flow is of broad applicability and can apply in may different sectors beyond the operations centres specifically being considered here.

5.5 OODA Loop and the Action Cycle

I have used the processes of Observe, Orientate, Decide and Act **(**OODA Loop) postulated by Boyd (Osinga, 1995) as a conceptual framework for supporting the flow of task-oriented communication and collaboration activities in the I-Room virtual worlds meeting spaces. The “Action Cycle” and “7 Stages of Action” described by Norman (2002, p 47) provides an insight into the same flow of activities using psychology terminology and approaches.

I mentioned earlier the “5E” learning cycle used by NASA and other science educators – Engage, Explore, Explain, Extend, Evaluate – and this can usefully be related to the performance of OODA Loop activities. Hence I believe that the I-Room can serve to support this cycle also when used in a training and educational context.

Linking this back to educational literature, this is similar to the “Experiential Learning” cycle advocated by Kolb (1984), based on the “Action Research” theories of Lewin (1946), and which involves a continuous cycle of concrete experience usually resulting from action in the world, followed by reflective observation, abstract conceptualisation or generalisation, and then active experimentation with the new model.

These theories relate to my own approach to collaborative activity support in a situation-based training context and suggest ways in which support can be given to those being trained.

SECTION 6 – MAPPING LEARNING OBJECTIVES TO APPROPRIATE LEARNER ACTIVITIES

I wish to induce appropriate learning in students in the social and situated context in which scenario-based training occurs. The choice of scenario element can be made to induce learner activity in a situational context most likely to be receptive to the student in their Zone of Proximal Development as suggested by Vygotsky (1934).

I want to consider overall learning objectives which can be achieved by encouraging suitable learner activities performed in a range of contexts to confirm learner understanding. An overall approach can be adopted from the "5E Instructional Model" (NASA, 2012) with a flow of Engage, Explore, Explain, Extend and Evaluate.

Within this higher level cycle, a very useful set of learner activities specifically relevant to situated and social activity in a community of practice has been developer by Soller (2001). They can provide a target set of learner activities for dealing with events in a mixed-initiative scenario-based training setting.

Active Learning	**Request**	Ask for help/advice in solving the problem, or in understanding a team-mate's comment.
	Inform	Direct or advance the conversation by providing information or advice.
	Motivate	Provide positive feedback and reinforcement.
Conversation	**Task**	Shift the current focus of the group to a new subtask or tool.
	Maintenance	Support group cohesion and peer involvement.
	Acknowledge	Inform peers that you read and/or appreciate their comments. Answer yes/no questions.
Creative Conflict	**Argue**	Reason (positively or negatively) about comments or suggestions made by team members.
	Mediate	Recommend an instructor intervene to answer a question.

Figure 6.1: Abstract Learner Activities from Soller (2001) – Definitions of Collaborative Learning Conversation Skills and Subskills

Soller's categories cover the types of collaborative interaction that takes place in fruitful learning engagements. It can be observed in many workshops and tutorial style meetings. People speak together, seek information, ask questions, seek clarifications, argue their viewpoints, propose options for activity, express issues with the positions others take, evaluate options, etc. Soller provides a more detailed level of analysis with a list of capabilities or skills which the learners may utilise. This "Collaborative Learning Conversation Skill Taxonomy" provides an important and useful set of learner (and tutor) activities along with example natural language phrases which typically introduce the activities she identifies.

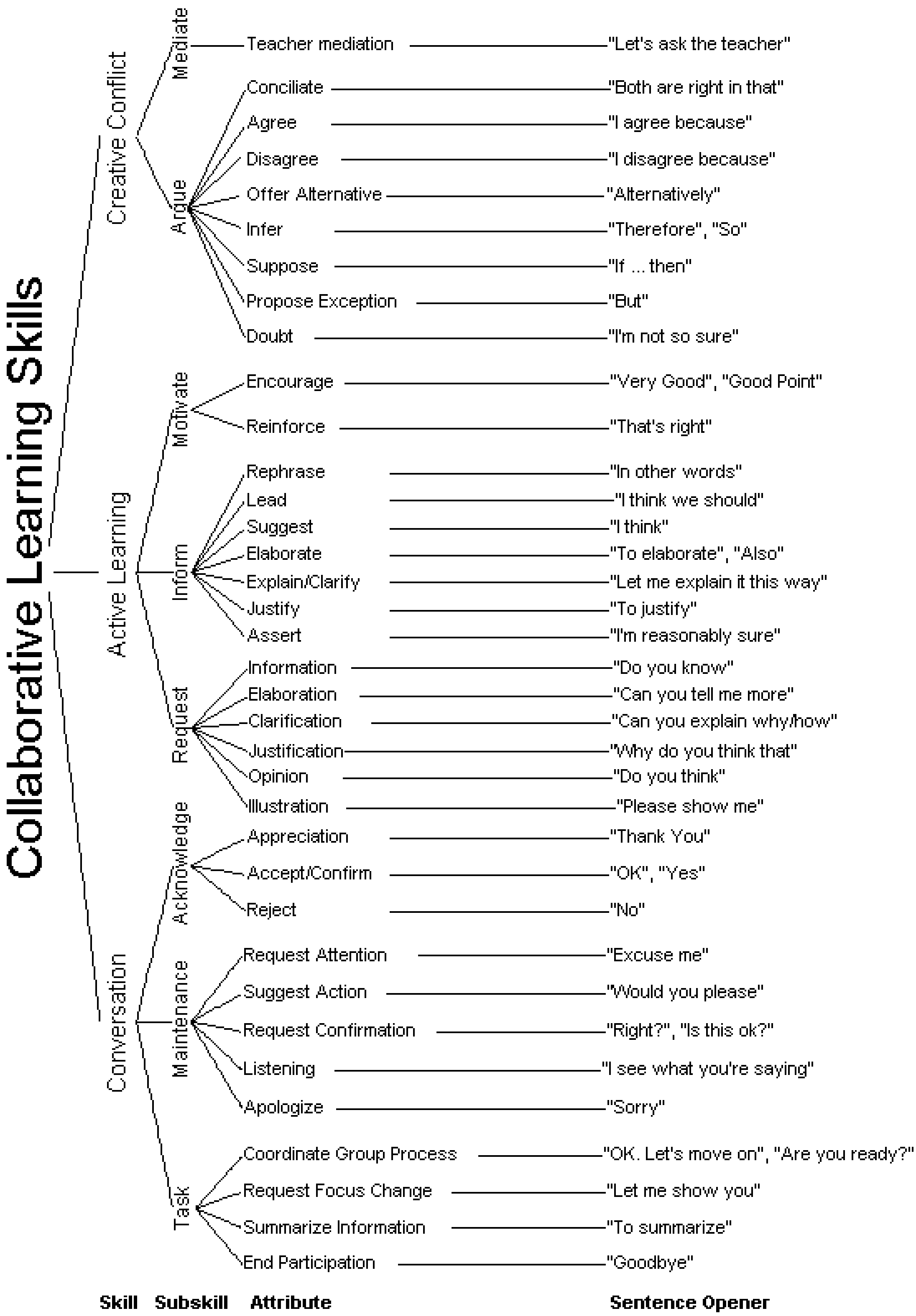

Figure 6.2: Detailed Learner Activities from Soller (2001) – The Collaborative Learning Conversation Skill Taxonomy

The set of activities suggests a natural set of inputs which may be injected into the training situation to maintain a mixed-initiative approach. Quite often scenario-based training involves ensuring that learners understand the importance of communications with others, confirming details, asking for clarification and elaboration, and careful transcription of messages from various sources.

In addition to the collaborative activities between the people involved, suitable scenario events can be selected at an appropriate time and injected into the situation to guide or reinforce learning are a key element. For example in a Search and Rescue training situation, the trainers might select events where two different pilots have ejected into the sea at different locations, but their call signs might be deliberately designed to cause potential confusion and mistakes unless the trainees use their standard operating procedures well. Briefing in advance gives clues, and a debrief afterwards can reinforce the lessons if mistakes had been made.

SECTION 7 – RELATING EDUCATIONAL AND DOMAIN LEVEL PLANS VIA ROAD MAPS

To provide a mechanism to relate learning objectives to scenario-based training activities in an application domain, I propose to adapt the techniques used in research programme "road mapping". Road maps have been used informally in many management and scientific contexts to show pathways and links where multiple levels of activity in an organisation or community can be planned, Technology Integration Experiments (TIEs) and Integrated Feasibility Demonstrations (IFDs) defined, research and development requirements and relationships identified, and more effective communication between participants achieved.

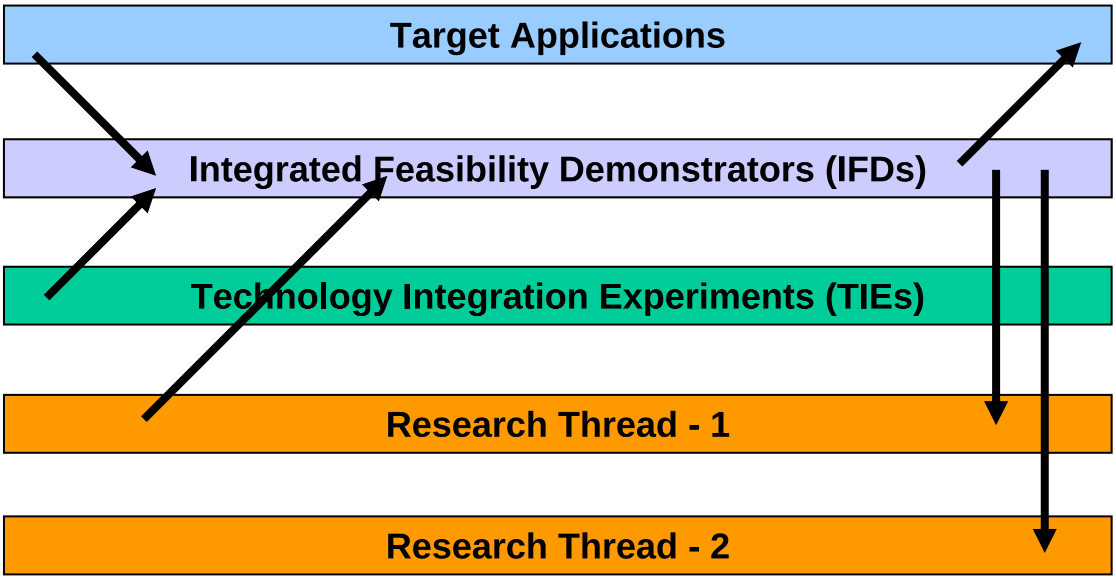

Figure 7.1: Generic Road Map Layers as used on the
US ARPA/Rome Laboratory Planning Initiative (ARPI, Tate, 1996c)

Road maps had been used in a number of large-scale US research programmes (e.g., Tate, 1996c) and were documented, adapted and used as a knowledge management methodology over a period of a decade or more by Tate (1993) and his colleagues in AIAI at the University of Edinburgh. Macintosh et al. (1998) describe the use of Knowledge Asset Road Maps in the following manner:

> "By carefully relating knowledge management actions upwards to business objectives and strategies, and downwards to specific knowledge assets, a co-ordinated picture of the various parts of an organisation's overall knowledge management programme can be visualized and justified. Knowledge Asset Road Maps used as a strategic planning tool, allow the gaps between an organisation's current know-how and future requirements to be identified, and informed investment decisions to close this gap to be made."

Road maps can describe multiple, but related, levels of plans, activities and state changes/effects. These can be at fundamentally different levels of abstraction including strategic, tactical and operational aspects. Each level is typically in a different domain and may have different types of activities involved.

The aim here is to adopt the idea of a road map and relate a plan for the educational objectives involved and the means to insert and achieve those, and a second plan which is made up of appropriate application domain level scenario-based training activities and events. This relationship can support choices of appropriate activities and events to chose.

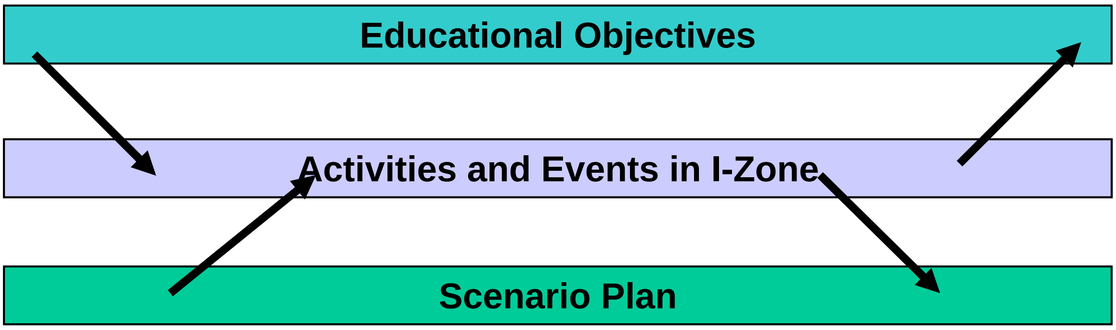

Figure 7.2: Example Road Map Threads adapted for Scenario-Based Training

Packages of scenario-based tasks can be made available and can be selected to fit into the application domain level (and hence have appropriate domain effects) and therefore seek to achieve the intended educational objectives or learning outcomes.

In a practical implementation, I envisage the creation of a system to maintain a model of the perceived educational outcomes/learner state, and to monitor the changes of state in the scenario application domain, to enable it to list the appropriate "next steps" – the contextualised activity appropriate to the situation and which can keep a learner in their Zone of Proximal Development, and which is also a plausible activity in a scenario sense.

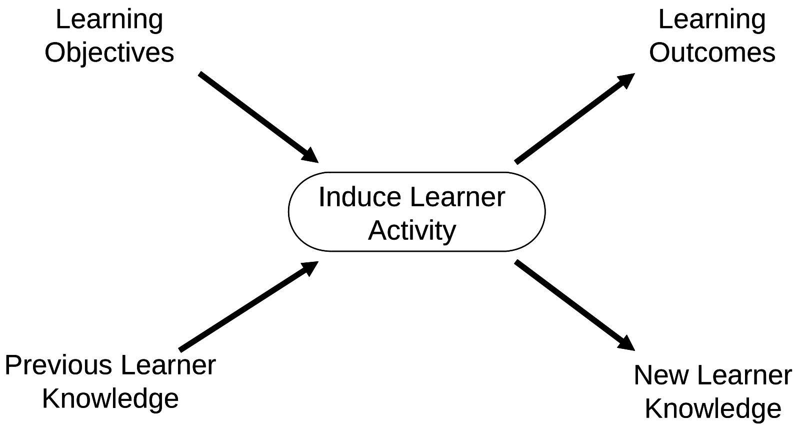

Figure 7.3: "4-Influences" Diagram from Tate (1993) adapted to describe Learner Activity in Context

I have adapted the "4-Influences" element from the knowledge asset road mapping methodology in Tate (1993) for the current purpose to show the key step involved – that we are seeking to induce appropriate activity in learners to maximally achieve the learning outcomes sought and achieve increased learner knowledge and experiences, given the context they begin in.

SECTION 8 – USING PLANNING TO COMPOSE LEARNING EPISODES

Even with the explicit linking of learning objectives and suitable scenario events and episodes which could relate to these, it is a difficult job to design training scenarios, especially given a variety of learners and their different levels of training and experience. This is exactly the sort of dynamic planning and choice selection focus which generative and adaptive AI planning technology addresses.

With the sort of domain model described earlier which incorporates a suitable vocabulary of learner activities and representation of the interactions of agents (students and tutors) in the learning situation, it may be possible to use AI planning methods to dynamically compose a learning episode, tailored to the situation or context, and the level of experience of the students. Appropriate domain events, issues and constraints can be injected via suitable scenario-based interventions to induce learner activity. The <I-N-C-A> ontology provides a representational framework for this. The "environment" or trainer's role-playing can add appropriate world state constraints (limited by the activity which is possible via the affordances offered) and inject relevant events for learners to respond to (as shown in figure 8.1).

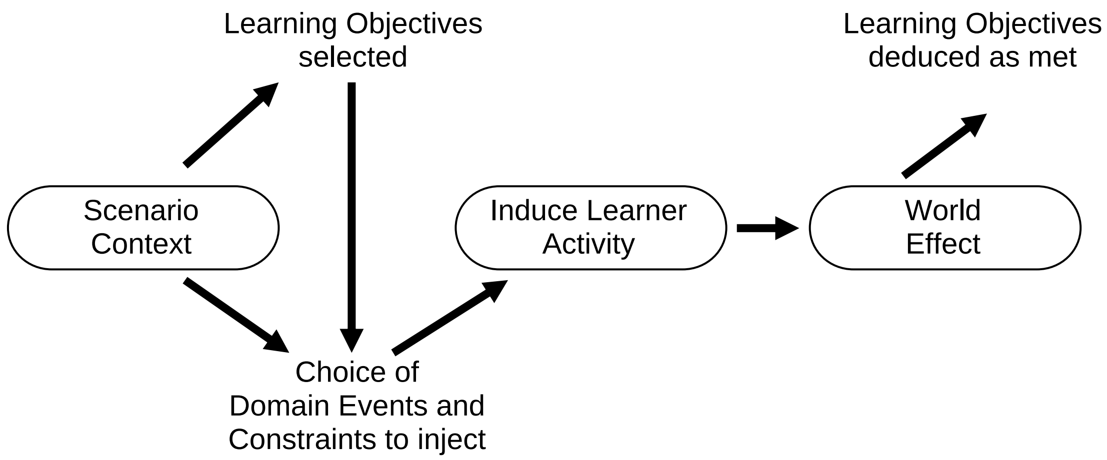

Figure 8.1: Choice of appropriate Issues and Constraints to inject to induce Learner Activity

Planning techniques as described here have already been used for workflow planning for inter-agent activity amongst distributed collaborative teams in command and control situations (Chen-Burger et al., 2004), in web services workflow composition (Uskok et al., 2004) and for creating adaptive tutoring sequences for an AI intelligent tutoring environment at Edinburgh (Zinn et al., 2002). The methods should be able to be adapted for use in the current application.

The use of AI generative planning technology to create and dynamically adapt tutorial plans and effective training episodes for learners in a mixed-initiative scenario-based training context could make a good basis for future PhD studies.

SECTION 9 – TRAINING CENTRES IN REAL LIFE

Before exploring simulated and virtual spaces for scenario-based training, it is useful to describe physical training centres used for training of emergency responders. Knowledge of these centres has informed work on virtual operations centres to support real distributed collaboration and as well as training exercises. This information has been gathered during work over more than two decades with military and civilian crisis response communities including the Search and Rescue (SAR) coordination centre for the UK Royal Air Force at Pitreavie in Scotland (Cottam et al., 1995), studies of city and regional level crisis response centres in Tokyo and Hampton, Virginia, and during US military joint forces SAR experiments (Tate et al., 2006).

9.1 Personnel Recovery Education and Training Center, Fredericksburg

A two year programme of research with the US Joint Forces Command (USJFCOM) Joint Personnel Recovery Agency (JPRA) Personnel Recovery Education and Training Center (PRETC) at Fredericksburg in Virginia (Wickler et al., 2007) and the requirements gathered during that experience greatly influenced the motivation for the current study.

At the PRETC training is provided for senior military personnel who are about to be deployed, often in far-flung areas of the world, where they will be expected to set up and run SAR coordination centres for complex multi-national and joint-forces missions.

A typical flow for the training is shown in the diagram below.

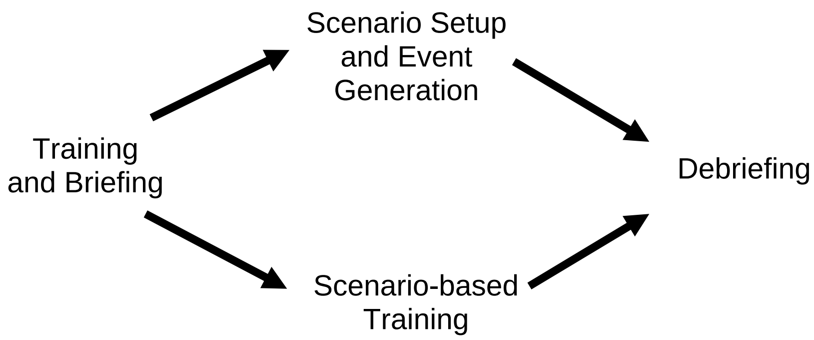

Figure 9.1: Typical Timetable of Activity in a PRETC Training Session

A classroom for lessons and scenario briefing and debriefing is augmented by a simulated training area, set up to resemble the sorts of operations centres which the trainees will encounter in real operations. This is arranged as a long communications corridor with rooms off it. One room usually represents the central SAR coordination centre and trainees take it in turns to “command” that centre during their training courses. Other rooms represent regional or component subsidiary rescue coordination centres (RCCs) and give trainees some idea of how communications to those units will be perceived when they are in operational SAR command situations.

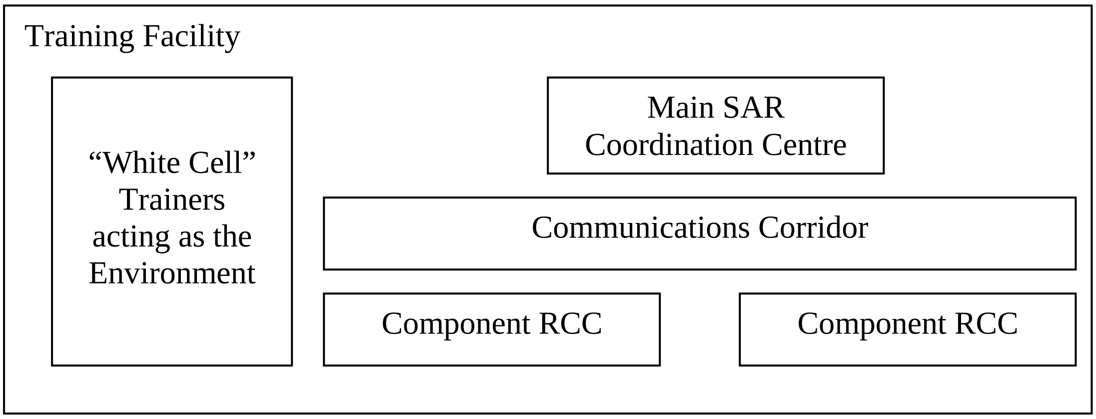

Figure 9.2: Conceptual Layout of Training Facility at PRETC, Fredericksburg, Virginia

Figure 9.3: Typical Search and Rescue Training Room – PRETC, Fredericksburg, Virginia showing typical whiteboards, forms, communications facilities, etc.

More details of the PRETC training facility are provided in Appendix A along with further information on other real operations centres of the sort used for search and rescue and emergency response.

9.2 "White Cell"

The environment in which the trainees operate is maintained and influenced via a number (perhaps a large number) of trainers who are located in what is called a "White Cell" (the colour relating to military terminology where typically blue refers to friendly forces, red hostile and grey neutral). The trainees communicate with this white cell via telephone, radio, fax, hand courier, etc. just as they would with real external agencies and the physical environment.

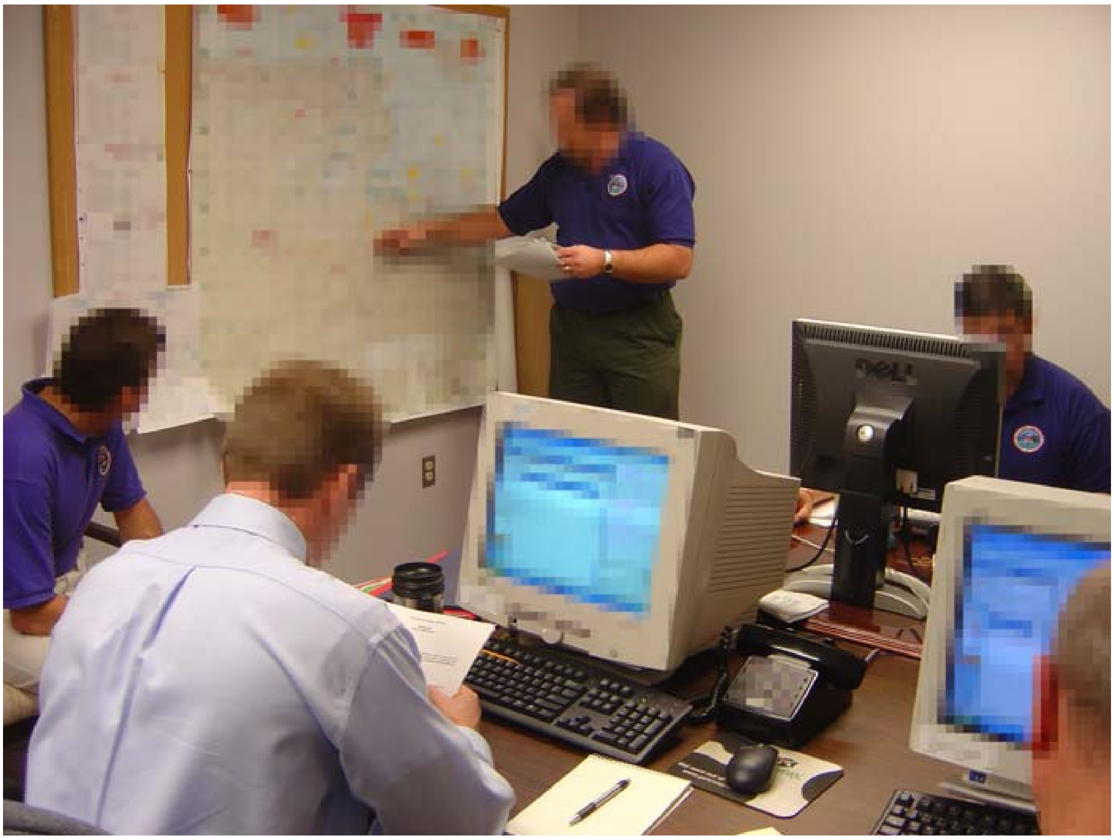

Figure 9.4: Trainers and Scenario Guidance Assistants in White Cell for Search and Rescue Training at the PRETC, Frederickburg, Virginia. Master Scenario Events List (MSEL) and Scenario Map are on the Wall

Trainers in the White Cell may use a "Master Scenario Events List" (MSEL) as often employed in scenario-based professional training (EMI-SIG, 2012) to provide a list of scenario-relevant events and messages to inject at appropriate times and in a suitable and natural way in the training exercise. Much effort can go into the creation of the MSEL to provide quality training.

SECTION 10 – I-ZONE REALISATION

An aim of the current study is to conduct an outline exploration, sufficient to allow for development by others later, of the technologies that might be appropriate to provide a realisation or implementation of an "I-Zone" and virtual classroom tutor or scenario assistant role players within it.

As a concrete focus for the study, I have been exploring technologies which could be used to embody an AI classroom assistant in a social space in a virtual world. The aim of the assistant would be to make use of good educational techniques which have proven effective to support training tasks in the virtual space and allow it to engage in mixed-initiative support of the learners within that space.

The availability of a realistic rendering of the environment on which training occurs can be a very important element in encouraging effective situated learning in a social context. There are a number of levels at which this can be provided and each has been the subject of experimentation during these studies.

10.1 Levels of Realisation and Embodiment

Figure 10.1 shows a number of distinct "levels" at which realisation and embodiment can be provided.

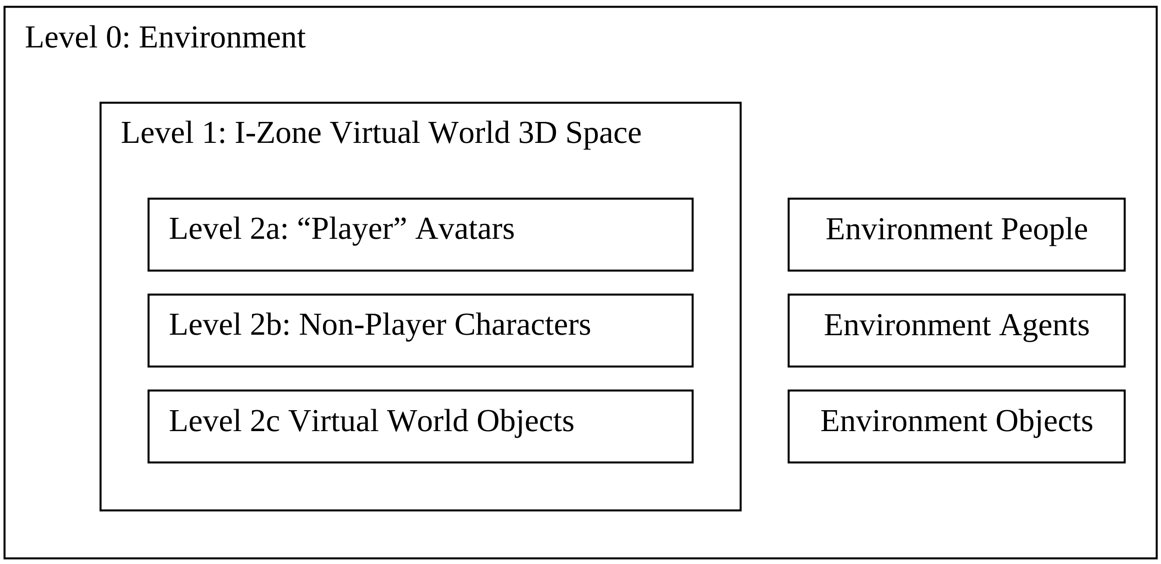

Figure 10.1: I-Zone – Levels of Realisation and Embodiment

The main training space, as envisaged in this dissertation, is provided by an "I-Zone" at "Level 1" which is a simulation of an operations or command centre within which training takes place. Information is received, tasks are assigned, communications occur and decisions are made which can have an impact on the current world state in which the training takes place. This sits within the environment representing the scenario itself – labelled "Level 0" – which is usually a simulation of the situation, but can in some circumstances be the real world itself with real people and equipment being guided during the training exercise, or be a mixture of synthetic agents and real agents or equipment.

Within the main I-Zone 3D virtual operation centre, there is a key element labelled "Level 2a" of embodiment represented by the learner's own avatar, and the avatars of others who they interact with. It is often useful to have role-playing ancillary agents and technical support agents, who are "Non-Player Characters" (NPCs) and may have limited interactivity that is understood by the main players in the scenario. This can radically reduce the costs of scenario-based training by not requiring human control of such agent functionality, yet provide realism for the interactions to be taught and used in the training situation. These NPC-style agents are labelled as "Level 2b". In some situations the active entities are best represented by realistically performing objects or equipment in the virtual world rather than human-in-appearance NPC avatars and agents. These virtual world objects are labelled as "Level 2c" in figure 10.1.

10.2 Level 0: Realisation of the Environment

The environment in which training takes place can be as simple as a written description of the situation at hand, perhaps augmented by maps. But it can also be a highly detailed computer simulation of the world in which training is occurring, with dynamic events being introduced, etc. In physical or mixed-reality training situations, the trainees may deal with actual entities in the real world or environment.

10.3 Level 1: Realisation of the Operations Centre – The I-Zone

The 3D virtual world space in which training occurs simulates an operations centre or command centre typical of those which the trainees will encounter in their work. The I-Zone virtual space realisation is based on the visual appearance of a typical operations centre used for command and control and for emergency response in real life and for scenario-based exercises. The layout has been based on the real operations centres described earlier and elaborated upon in Appendix A.

The resulting virtual space provides a multi-zone facility with a central area for the main planning and decision making team, and four closely associated functional zones for specific types of work: sensing and situation assessment, option generation and plan argumentation, decision making, and plan enactment and communications – supporting the methodology of the OODA Loop. It includes peripheral areas for observers, tutors and technical assistance people to be explicitly present in the virtual meeting space, as well as external recording and monitoring of exercises where appropriate. There is a large area of wall space on which display screens, posters and equipment can be mounted.

The 3D virtual world space can be an alternative to conceptual persistent 3D spaces maintained "in the head" from text descriptions such as used in MUD1 (Bartle, 1990) and LambdaMOO (LambdaMoo, 2012). But the I-Zone combines both, giving a 3D physical and sensory realisation of an operations centre and an imagined environment beyond, which can be realistically maintained and interacted with via the team of trainers involved (in the white cell).

The “core plus modules” shape of the I-Zone itself arose through experience of well-designed facilities which encourage social and professional interaction in advanced research centres such as Xerox PARC, and the design of research environments in Edinburgh University’s Appleton Tower’s refurbishment to house research institutes.

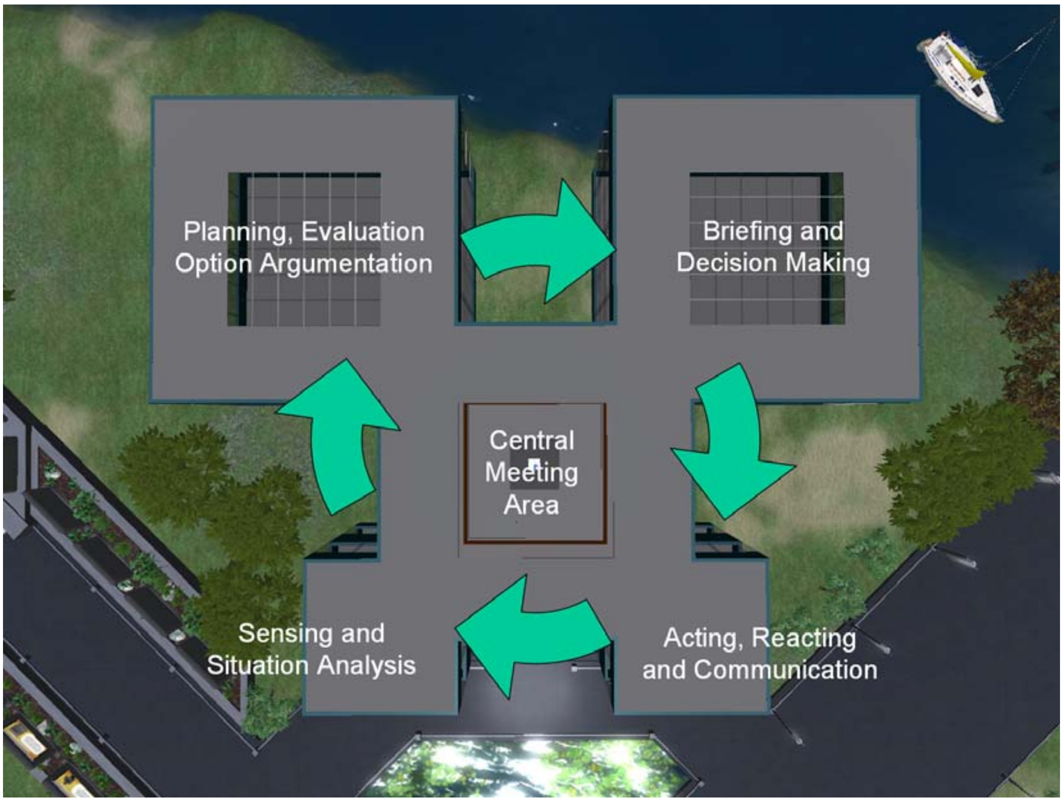

Figure 10.2: I-Room – Central Meeting and Functional Zones –
Support for the OODA Loop

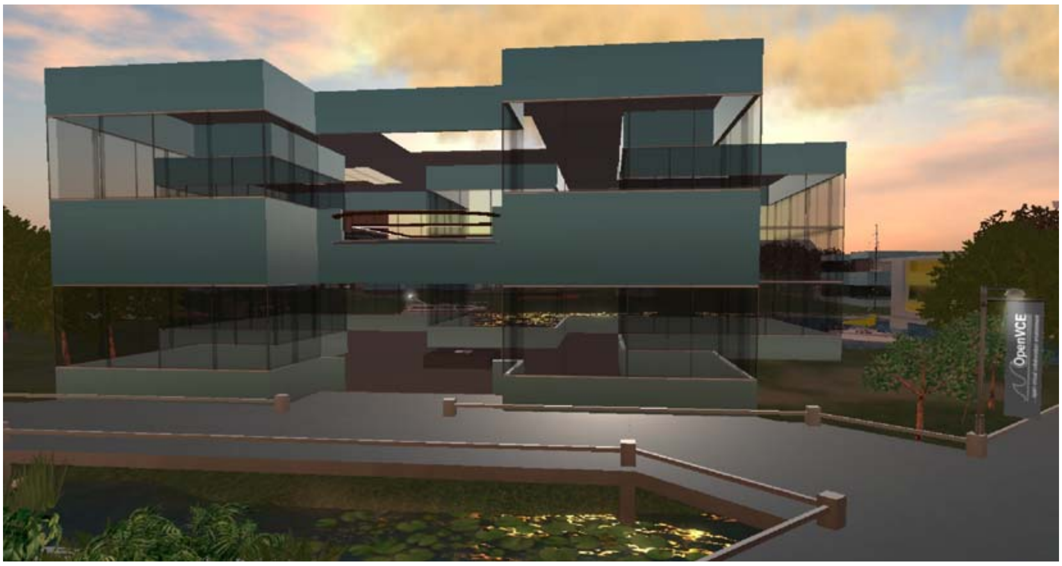

Figure 10.3: I-Room Exterior showing Central Area and each corner Work Zone

Figure 10.4: Example I-Room in use for an Emergency Response Incident Training Scenario

10.4 Level 2a: Embodiment of the Player Avatar

Perhaps the most important level of embodiment is the representation of the role of the trainee themselves in the situation. This is provided by a human-like and plausible avatar which represents the identity of the trainee to themselves and to the other people involved in the situation. There is much evidence that a properly presented avatar can lead to high levels of engagement and immersion in such an environment (Turkle, 1995; Hayles, 1999; Gee, 2003; Castronova, 2005; Cleland, 2010) and can trigger a number of important motivational factors (Malone,1981) which can help learning. The level of engagement goes beyond the visual appearance of the avatar, as is witnessed by the levels of motivation and immersion possible even when using characters in text-based virtual environments (Bartle, 2005; Vicdan and Ulusoy, 2008).

10.5 Level 2b: Embodiment of Non-Player Characters (NPC)

To provide a social environment populated by other relevant characters in an interactive training situation it has in the past been necessary to have a number (sometimes a large number) of other people and trainers involved in role playing and acting out a set of support roles such as to move simulated vehicles and manipulate simulated objects in plausible ways to respond to the activities of those being trained. This is feasible in high value simulations and infrequent large-scale scenario-based exercises, often undertaken by the military and organisations concerned with business continuity in the event of major disruptions. But we wish to provide lower costs and less labour-intensive means to support situation-based training.

A means to do this is to provide plausible human-like computer-controlled characters and vehicles which can be active and reactive agents for change in the environment.

Many computer games now provide plausible non-player characters to perform the role of quest givers, information providers, opposing players or team mates in single player games or to augment interactions with real players who link up via the internet in multi-player games. Larger scale military simulations are now often equipped with very large numbers of "synthetic forces" to make the situation realistic. An example is in the work on DARPA's Synthetic Theater of War '97 (STOW-97) demonstration and its use of SOAR-agent Intelligent Forces (Hill et al., 1997). Use of simulation-based training which employs teams of "synthetic agents" to provide the surrounding realistic context and push learners into the appropriate learning pathways has also been studied at USC ISI in California over the years (e.g., Traum et al., 2003).

I was involved in a project under the "UK Alvey Programme" in the 1980s with Rediffusion Simulation and others which involved training naval officers commanding their ships in complex shipping lanes such as the English Channel. The ship bridge simulator in which the person being trained was placed was surrounded by a very comprehensive environment largely made up of people who guided other ships and vehicles, and injected dynamic events into the training scenario. The project was trying to provide some scripted and reactive intelligent agents to reduce significantly the costs of providing this sort of training envelope. The role of the trainers was really to constrain the environment and change it as the trainee made decisions to keep him or her "on track" to force a position where certain decisions were before the trainee and that had to be confronted. If the trainee got out of the situation too easily, the trainers changed things to get the trainee back into a zone where they could most usefully learn. There was therefore a plausible real situated world in which the trainee had a space of decisions, but these were grounded in a picture around the trainee and not in some abstract formulation.

10.6 Level 2c: Representation of Objects and Equipment

It is not necessarily always best to have a human-shaped avatar or NPC to act as the basis for knowledge-based assistance or interaction in the I-Zone. Objects in the world can simulate the type of equipment which the trainees might interact with in the role they are being trained for.

In previous I-Room applications, intelligent and knowledge-based systems support has been provided through an I-Room Helper object typically modelled, for example, as a conference phone on the central desk (Tate, 2011a).

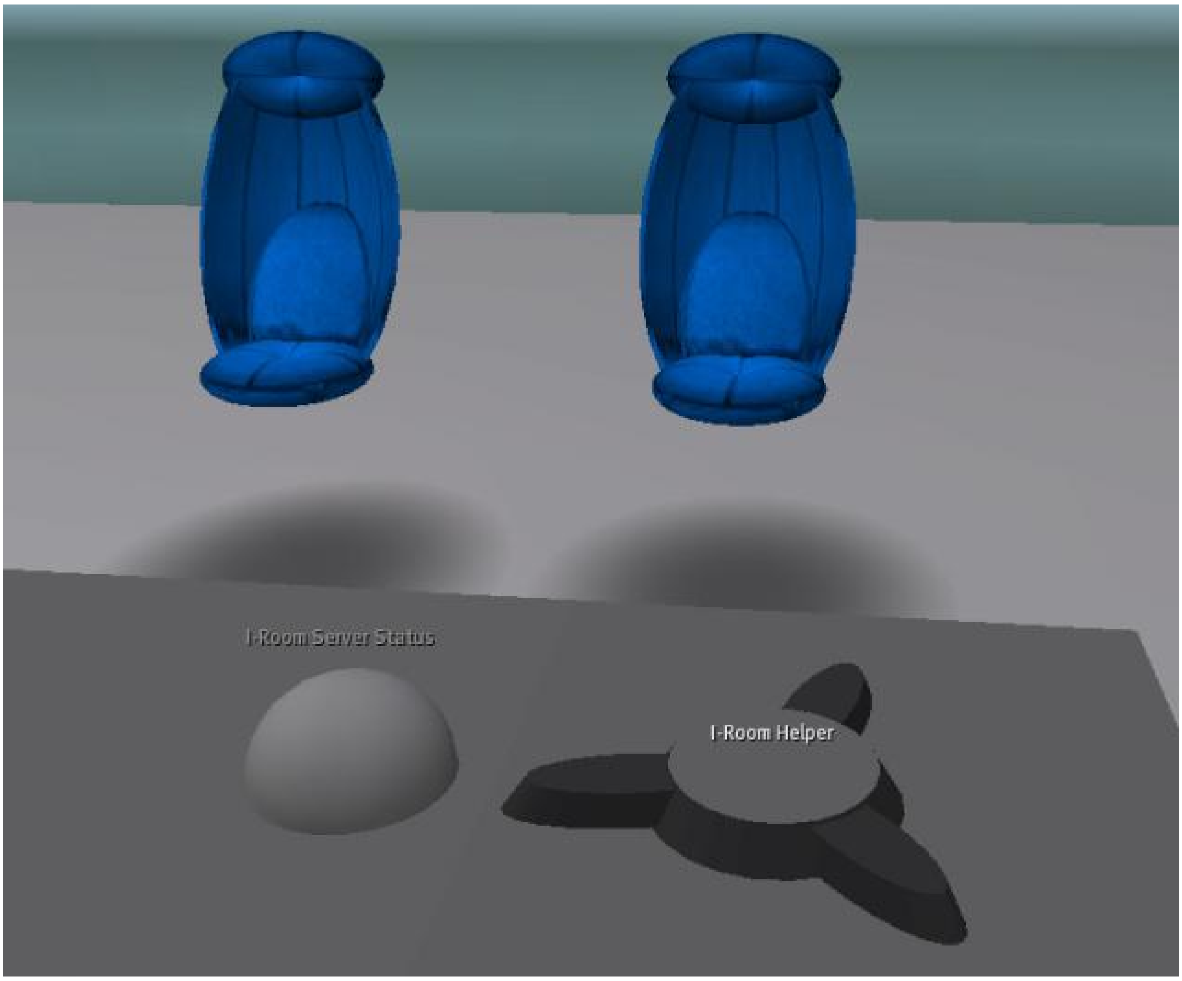

Figure 10.5: Virtual Object: I-Room Helper in Conference Phone Style Object

10.7 Level -1: The Trainers' Viewpoint

As previously discussed, to provide a realistic situation for training, a possibly large number of people outside the operations or command centre might be used to control the entities and how they act and respond to decisions made and communications from those in the training room. Often a "White Cell" is created in which the trainers and scenario specialists control the environment around the operations centre in which the trainees operate. As previously mentioned, the people in such a white cell provide inputs to support trainers by making use of a Master Scenario Events List (MSEL) to drive the simulation and keep learners "on track" for the learning objectives sought.

A separate viewing or control area both within and outside the virtual world can be made available to allow for observation of the scenario-based training episodes, to allow for interventions where necessary. Intervention can be arranged via in-world facilities and appropriate communications methods to make the situation more realistic and immersive. Peripheral observer seating areas are made available in the I-Zone, as the trainees in crisis and emergency response operations centres are often familiar with observers in their real environments.

SECTION 11 – VIRTUAL CLASSROOM ASSISTANT EMBODIMENT

As part of this study a number of technologies have been explored to ensure that a suitable basis would be available to provide an embodiment for a classroom assistant in a virtual world like Second Life or OpenSimulator, but potentially using facilities that could be provided in any suitably open scripted virtual world in future.

This has involved the following elements, which have been examined in sufficient detail to ensure that resources are available and identified, that preliminary investigations indicate they could work in the AI classroom assistant context, and that a simple demonstration has been performed to check the facilities out.

1. Avatar Embodiment without user monitoring or login – using OpenSimulator Non-Player Character (NPC) technology.

2. Chatbot facility for answering questions and giving guidance – using Pandorabot (ALICE) and MyCyberTwin chatbot frameworks.

3. Link to external knowledge-based systems, activity planning and task or procedure following aids, and natural language text chat generation – using the I-X Technology Helper.

4. Link-up with a Virtual Learning Environment (VLE) such as Moodle, or a collaborative community web portal such as OpenVCE.net.

11.1 Non-Player Character (NPC) Technology

In work to support scenario-based training and experimentation on the Open Virtual Collaboration Environment project, we have utilized role-playing avatars within our meeting spaces and experimental I-Rooms to assist in the conduct of the meeting or experiment. These role-specific avatars are used for technical assistance and to act as "camera person" relays to observers and are usually driven by support staff. But an aim has been to semi-automate some aspects of these role playing characters. There is also a specific meeting support "object" in the form of a conference style phone in the meeting space connected to external meeting logging and knowledge-based support aids (Tate, 2011a). Such meeting room assistants have been connected using I-X technology to AI planning and meeting support services to perform a variety of roles. See Appendix B for examples.

Some preliminary work has been performed during this study to explore the use of "non-player characters" (NPCs) and evaluate the technology emerging during 2012 to allow for the creation of NPC "cloned" avatars in OpenSimulator. Details of the technology employed and links to further information are included in Appendix B.

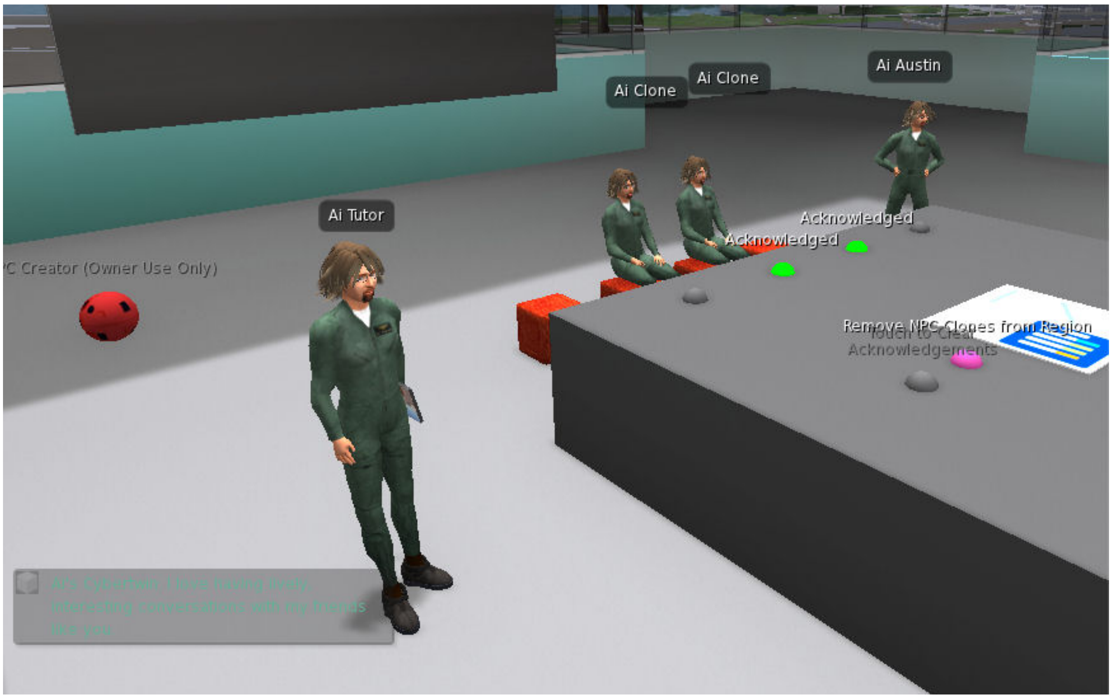

Figure 11.1: NPC Avatar Tutor with “tablet” link to MyCyberTwin chatbot and seated NPCs

The NPC cloned avatar created is based on any avatar appearance complete with all clothing and attachments. The attachments are an important element, as they allow objects to be attached to the NPC which can act as a chat and activity relay to web services, or AI systems such as planning aids.

To allow for a more natural meeting room assistant, a way to have the clone seat itself on a nominated object was provided. Finally, code to make the cloned avatar persist over OpenSimulator server restarts and upgrades was provided to ensure that the cloned avatar can stay in place and be present when required without manual intervention or requiring the original avatar to log in to recreate the NPC.

11.2 Virtual Classroom Assistant Chatbots

One use of the ability to connect non-player characters classroom assistants or tutors to external web services has been to connect the NPC to a chatbot facility. As a demonstration, an attachment looking like a handheld tablet computer has been attached to a NPC avatar before the clone is made. This attachment acts as a connection via the NPC to an on-line chatbot service using a web link script which can listen for communications on a text chat channel, providing a capability to answer frequently asked questions and provide assistance for some types of regular requirements.

Such a tablet attachment or others such as a badge on the avatar can trigger activity in other objects in the room, such as acknowledging the NPC is present, or indicating that connected web services are live. Connections can be made to external facilities such as web portals, social networks, virtual learning environments, external knowledge-based systems, community knowledge bases containing Standard

Operating Procedures and checklists, and AI planners to provide assistance and adaptive tutorial support in a training facility.

More details of the experiments and demonstration access to the live chatbot facilities using Pandorabot and MyCyberTwin chatbot technology are described in Appendix B.

11.3 Virtual Classroom Assistant Knowledge-Based Services

In previous work, links from a virtual world meeting space to external knowledge-based systems, activity planning and task or procedure following aids, natural language text chat generation have been explored (Tate et al., 2010a) using an "I-X Helper" object in world which can support users in the facility to gain access to procedural assistance, external knowledge sources, image and video media, etc. The Helper can make use of in-world capabilities such as display screens, text chat, instant messaging, and scripted control of objects to perform a range of functions on request (Tate, 2011a).

11.4 Virtual Classroom Assistant Link to Virtual Learning Environments

Links from a virtual classroom assistant to the Moodle Virtual Learning Environment (VLE) using the SLoodle module to link Moodle to Second Life and OpenSimulator classrooms (Livingstone and Kemp, 2008) have also been explored to provide in-world facilities in a scenario-based virtual training situation. In particular a generic module has been adapted to act as a flexible framework for adding AI classroom assistant functionality which can utilise and modify course and participant information from the Moodle VLE. A diary of experimentation to date on Moodle and SLoodle is available via the Moodle tag on blog posts at http://holyroodpark.net/atate/weblog and a compilation has been made available in Tate (2011c).

SECTION 12 – SUMMARY AND FUTURE DEVELOPMENTS

My studies have focused on readings in cognitive psychology which could inform scenario-based training employing a mixed-initiative training style rather than top-down tutor guided learning or entirely bottom-up discovery-based learning by students. I have also learned about early work on artificial intelligence as applied to education and tutoring systems to understand the techniques which are employed. I have related this body of work to my own previous practically motivated work on knowledge rich plan representations and the underlying conceptualisation employed in my research. A road-mapping methodology of relating learning objectives and their desired outcomes to scenario-based learner activity in a suitable social and situated context to improve the knowledge and experience of the student has been described. An educational game-based research informed work flow and lexicon of learner activities relevant to community scenario-based learning context have been identified. A choice of scenario context to set up and events or activities to inject can be made in this framework to present a challenging and meaningful situation to the students in an immersive and embodied realisation of an operations centre in a 3D virtual world.

During the course of the study an approach to support scenario generation and adaptation in a mixed-initiative situated training context has been made explicit. This comprises:

a) an ***embodiment*** of the target training situation which allows for an immersive and engaging user experience;

b) employ natural ***constraints*** "in the world" for what can and cannot be done via interaction with the environment through appropriate scenario setup and provision of situation realistic devices and communications mechanisms, and which provide natural affordances on what activity can be performed;

c) set up of appropriate, realistic, challenging and motivational ***tasks or objectives*** within the scenario guided by the learning objectives desired;

d) carefully select and inject scenario ***events*** into the training situation to maintain interest and keep learners "in the zone" for effective learning;

e) induce appropriate ***context-specific activity*** by the learners to respond to the situation they find themselves in.

The approach is grounded in a rigorous yet conceptually simple ontology representing plans, activities, processes and agents, and their interactions. This representation can handle relevant objectives being stated in a dynamically changing world state. This allows the potential for using generative AI planning technology in the creation and dynamic adaptation of training episodes. It allows for AI-driven non-player characters to be introduced which can participate effectively in the mixed-initiative evolving scenario.

The methodology can be summarised as:

- **constrain** the world situation and the affordances it presents;
- **inject** tasks, issues and events; and
- **induce** learner activity in context.

Within an “I-Zone” virtual scenario-based training space, the use of Non-Player Character (NPC) technology has been explored to provide an embodiment of a virtual classroom assistant. Some key methods for providing a range of interactivity and knowledge-based tutoring support have been added. These include chatbot technology for answering frequently asked questions and providing helpful guidance and links, chat logging, links to knowledge-based systems and AI planning support and links to a virtual learning environment.

I have explored the framework in the context of applications to training for crisis and emergency response, but it has potential in other domains. Those engaged in medical training, for example, are also required to design well crafted scenario elements which stretch the knowledge, experience and skill of the trainees. There is a growing body of work on the use of virtual environments for medical training purposes (Boulos et al., 2007). “Virtual Patient” embodiments – both instrumented physical dummies and computer generated versions – are used in the field of medicine for this purpose.

The framework, methodology and experiments described in this dissertation and the virtual worlds embodiment experiments performed are intended to provide a conceptual and technological resource base for potential collaborative research projects and ideas for student projects in future.

REFERENCES

Aarup, M., Arentoft, M.M., Parrod, Y., Stokes, I., Vadon, H. and Stader, J. (1994) "Optimum-AIV: A Knowledge-Based Planning and Scheduling System for Spacecraft AIV", in Intelligent Scheduling (eds. Zweben, M. and Fox, M.S.), pp. 451-469, Morgan Kaufmann.

Ackermamnn, E. (2001) "Piaget's Constructivism, Papert's Constructionism: What's the Difference?" Constructionism: Uses and Perspectives in Education, Conference Proceedings, Geneva, September 2011). Also available as MIT Future of Learning Group Publication, Vol. 5 No. 3, p.438. http://learning.media.mit.edu/content/publications/EA.Piaget%20_%20Papert.pdf

Agre, P. and Chapman, D. (1989) "What are Plans for?", Massachusetts Institute of Technology Artificial Intelligence Laboratory, MIT A.I. Memo 1050a, October 1989.

Bandura, A. (1977) "Social Learning Theory", Prentice-Hall.

Barab, S., Arici, A. and Jackson, C. (2005) "Eat Your Vegetables and Do Your Homework: A Design-Based Investigation of Enjoyment and meaning in Learning", Educational Technology, January-February 2005, pp. 15-21.

Barsalou, L.W. (1999a) "Language Comprehension: Archival Memory or Preparation for Situated Action", Discourse Processes Vol. 28, pp. 61-80. http://psychology.emory.edu/cognition/barsalou/papers/Barsalou_DP_1999_situated_comprehension.pdf

Barsalou, L.W. (1999b) "Perceptual Symbol Systems", Behavioral and Brain Sciences Vol. 22, pp. 577-660. http://psychology.emory.edu/cognition/barsalou/papers/Barsalou_BBS_1999_perceptual_symbol_systems.pdf

Bartle, R.A. (1990) "Early MUD History". http://www.mud.co.uk/richard/mudhist.htm

Bartle, R.A. (1995) "Richard Bartle on Text, Graphics, and Virtual Worlds|", Clickable Culture Blog, Post via Tony Walsh, 14-Aug-2005. http://www.secretlair.com/index.php?/clickableculture/entry/richard_bartle_on_text_graphics_and_virtual_worlds/

Borwarnginn, P. (2012) "Knowledge-based Systems and Social Constructivism to Improve an Virtual Intelligent Collaborative Learning Environment", Ph.D. Thesis Proposal, School of Informatics, University of Edinburgh, June 2012. http://openvce.net/ile-proposal

Boulos, M.N.K., Hetherington, L. and Wheeler, S. (2007) "Second Life: an overview of the potential of 3-D virtual worlds in medical and health education", Health Information and Libraries Journal Vol. 24, pp.233–245, Blackwell Publishing Ltd. http://onlinelibrary.wiley.com/doi/10.1111/j.1471-1842.2007.00733.x/pdf

Bransford, J.D. and Schwartz, D.L. (1999) "Rethinking Transfer: A Simple Proposal with Multiple Implications", Review of Research in Education, Chapter 3, Vol. 24, pp. 61-100, (Iran-Nejad, A. and Pearson, P.D., eds.), American Educational Research Association (AERA) Washington, DC, USA. http://www.stanford.edu/~danls/RethinkingTransfer.pdf

Brown, A.L. and Campione, J.C. (1994) “Guided discovery in a community of learners”, in K. McGilly (ed.), Classroom Lessons: Integrating Cognitive Theory and Classroom Practice (pp. 229–270), MIT Press/Bradford Books. http://www.cogsci.ucsd.edu/~deak/classes/EDS115/brown_campione2_ps.pdf

Burton, R.R. (1982) “Diagnosing Bugs in a Simple procedural Skill”, in “Intelligent Tutoring Systems”, (eds.) D. Sleeman, D. and J.S.Brown, pp. 159-184, Academic Press.

Burton, R.R. and Brown, J.S. (1982) “An Investigation of Computer Coaching for Informal Learning Activities”, in “Intelligent Tutoring Systems”, (eds.) D. Sleeman and J.S. Brown, pp. 79-98, Academic Press.

Bybee, R.W. (2009) “The BSCS 5E Instructional Model and 21st Century Skills”, Biological Sciences Curriculum Study (BSCS), January 2009, for Workshop on Exploring the Intersection of Science Education and the Development of 21st Century Skills. http://www7.nationalacademies.org/bose/Bybee_21st%20Century_Paper.pdf

Camilleri, V. and Montebello, M. (2008) “SLAVE – Second Life Assistant in a Virtual Environment”, in Proceedings of the Researching Learning in Virtual Environments International Conference (ReLIVE 08), 20-21 November 2008, The Open University, UK, pp. 72-93.

Carbonell, J. R. (1970) “AI in CAI: An Artificial Intelligence Approach to Computer-Assisted Instruction”, IEEE Transactions on Man-Machine Systems, Vol. 11, No. 4, pp. 190-202.

Carroll, J.M., Kellogg, W.A. and Rosson, M.N. (1991) “The Task-Artifact Cycle”, in “Designing Interaction: Psychology at the Human Computer Interface” (ed. J.M.Carroll), pp. 74–102, Cambridge University Press, New York.

Carroll, J.M. and Rosson, M.N. (1992) “Getting Around the Task-Artifact - How to Make Claims and Design”, ACM Transactions on Information Systems, Vol. 10, No. 2, pp. 181-212, April 1992. http://informatix.ida.liu.se/~HIIA67/info/p181-carroll.pdf

Castronova, E. (2005) “Synthetic Worlds: the Business and Culture of Online Games”, University of Chicago Press.

Chen-Burger, Y-H., Hui, K., Preece, A.D., Gray, P.M.D. and Tate, A. (2004) “Workflow Collaboration with Constraint Solving Capabilities”, Poster at the British Computer Society Specialist Group on Artificial Intelligence Conference (AI-2004), Cambridge, December 2004.

Cleland, K. (2010) “Prosthetic Bodies and Virtual Cyborgs”, Second Nature, Issue No. 3, March 2010. http://www.kathycleland.com/wp-content/uploads/Cleland_Prosthetic_Bodies.pdf

Clinton, J. (2008) “Using Non-Player Characters as Tutors in Virtual Environments”, in Proceedings of the Researching Learning in Virtual Environments International

Conference (ReLIVE 08), 20-21 November 2008, The Open University, UK, pp. 181-188.

Conklin, J. (2005) “Dialogue Mapping: Building Shared Understanding of Wicked Problems”, John Wiley.

Cottam, H., Shadbolt, N., Kingston, J., Beck, H. and Tate, A. (1995) “Knowledge Level Planning in the Search and Rescue Domain”, Proceedings of Expert Systems 95 Conference, Cambridge, 1995.
http://www.aiai.ed.ac.uk/project/oplan/documents/1995/95-es95-plan-rescue.pdf

Currie, K.W. and Tate, A. (1991) “O-Plan: the Open Planning Architecture”, Artificial Intelligence 52(1), Autumn 1991, North-Holland.
http://www.aiai.ed.ac.uk/project/oplan/documents/1991/91-aij-oplan-as-published.pdf

Dawley, L. (2009) “Social Network Knowledge Construction: Emerging Virtual World Pedagogy”, On the Horizon, Vol. 17 No. 2, pp. 109-121, Emerald Group.
http://edtech.boisestate.edu/ldawley/SNKC_pdf.pdf

Erikson, E.H. (1977) “Toys and Reasons: Stages in the Ritualization of Experience”, W.W.Horton.

EMI-SIG (2012) “What is a Master Scenario Events List?”, Exercise Builder - A Tool for Emergency Exercise/Drill Development”, Emergency Management Issues Special Interest Group (EMI-SIG), Oak Ridge Institute for Science and Education (ORISE), U.S. Department of Energy (DoE).
http://orise.orau.gov/emi/training-products/exercisebuilder/support/help/step06.htm

Games, A. (2011) “Play It Forward” in “How To Bring Serious Games Into The Classroom”, e-Newsletter 2nd November 2011. http://www.edutopia.org/ and http://www.edutopia.org/blog/new-xbox-games-for-learning-alex-games

Gee, J.P. (2005) “Affinity Spaces: From Age of Mythology to Today's Schools”, in D. Barton & K. Tusting (eds.), Beyond communities of practice: Language, power and social context, pp. 214-232, Cambridge University Press.
http://www.jamespaulgee.com/sites/default/files/pub/AffinitySpaces.pdf

Gee, J.P. (2003) “Learning and Identity: what does it mean to be a half-elf?” from “What video games have to teach us about learning and literacy”, pp 51-71, Basingstoke: Palgrave Macmillan.

Gee, J.P. (2007) “What video games have to teach us about learning and literacy”, revised edition, Palgrave Macmillan. Original edition 2003.

Gee, J.P. (2008) “Learning and Games”, in “The Ecology of Games: Connecting Youth, Games, and Learning”, K. Salen (ed.), The John D. and Catherine T. MacArthur Foundation Series on Digital Media and Learning, MIT Press.

Gee, J.P. (2012) "James Paul Gee on Learning with Video Games", Talk to Edutopia.org uploaded to YouTube on 21-Mar-2012. http://www.youtube.com/watch?v=JnEN2Sm4IIQ

Gibson, J. J. (1977) "The Theory of Affordances", in R. E. Shaw & J. Bransford (Eds.), Perceiving, Acting, and Knowing, Lawrence Erlbaum Associates.

Gibson, J. J. (1979) "The Ecological Approach to Visual Perception", Houghton Mifflin.

Gough, D., Thomas, J., and Oliver, S. (2012) "Clarifying Differences between Review Designs and mMethods", Systematic Reviews, Vol 1., No 1, Paper 28. http://www.systematicreviewsjournal.com/content/1/1/28

Greeno, J.G. and Moore, J.L. (1993) "Situativity and Symbols: Response to Vera and Simon", Cognitive Science, Vol. 17, pp. 49-59.

Han, L., Potter, S., Beckett, G., Pringle, G., Welch, S., Koo, S-H., Wickler, G., Usmani, A., Torero, J. and Tate, A. (2010) "FireGrid: An e-Infrastructure for Next-Generation Emergency Response Support", Journal of Parallel and Distributed Computing, 70 (2010) 1128-1141. http://firegrid.org

Hayles, N.K. (1999) "Toward Embodied Virtuality", Chapter 1 of "How We Became Posthuman: Virtual Bodies in Cybernetics, Literature and Informatics", pp 1-25, University of Chicago Press.

Hill Jr., R.W., Chen, J., Gratch, J., Rosenbloom,P. and Tambe, M. (1997) "Intelligent Agents for the Synthetic Battlefield: A Company of Rotary Wing Aircraft", in Proceedings of Innovative Applications of Artificial Intelligence (IAAI 2007). http://people.ict.usc.edu/~hill/hill-publications/IAAI-97.pdf

Jeffery, C. (2008) "Using Non-Player Characters as Tutors in Virtual Environments", in Proceedings of the Researching Learning in Virtual Environments International Conference (ReLIVE 08), 20-21 November 2008, The Open University, pp. 72-93. PDF).

Klein, G. (1998) "Sources of Power – How People Make Decisions", MIT Press.

Kolb, D.A. (1984) "Experiential Learning – Experience as the Source of Learning and Development", Prentice-Hall. See http://www.infed.org/biblio/b-explrn.htm

Knutilla, A., Schlenoff, C., Ray, S., Polyak, S.T., Tate, A., Cheah, S.C. and Anderson, R.C. (1998) "Process Specification Language: An Analysis of Existing Representations", NISTIR 6160, National Institute of Standards and Technology, Gaithersburg, MD, USA May 1998. http://www.mel.nist.gov/msidlibrary/doc/psl-1.pdf

LambdaMOO (2012) "LambdaMOO Wikipedia Entry". http://en.wikipedia.org/wiki/LambdaMOO

Lave, J. and Wenger, E. (1991) “Situated Learning: Legitimate Peripheral Participation”, Cambridge University Press.

Lee, J., Grunninger, M., Jin, Y., Malone, T., Tate, A., Yost, G. and other members of the PIF Working Group (1998), “The PIF Process Interchange Format and Framework, Version 1.2”, Knowledge Engineering Review Vol 13, No. 1, pp. 91-120, Cambridge University Press, March 1998.
http://www.aiai.ed.ac.uk/project/oplan/documents/1998/98-ker-lee-pif-1.2.rtf

Lester, J.C., Stone, B.A. and Stelling, G.D. (1999) “Lifelike Pedagogical Agents for Mixed-initiative Problem Solving in Constructivist Learning Environments”, User Modeling and User-Adapted Interaction, Vol. 9, pp. 1-44.
http://scienceview.berkeley.edu/research/agents/99.Lester.Stone.Stelling.pdf

Lewin, K. (1946) “Action Research and Minority Problems”, Journal of Social Issues Vol. 2, No. 4, pp. 34–46, November 1946.

Linden Labs. (2012) “Second Life”. http://secondlife.com

Johnson, W.L. and Rickel, J.W. (2000) “Animated Pedagogical Agents: Face-to-Face Interaction in Interactive Learning Environments”, International Journal of Artificial Intelligence in Education Vol. 11, pp. 47-78.
http://www.tacticallanguage.com/files/AIED00-animated_pedagogical.pdf

Livingstone, D. and Kemp, J. (2008) “Mixed-Methods and Mixed-Worlds: Engaging Globally Distributed User Groups for Extended Evaluation Studies”, in Proceedings of the Researching Learning in Virtual Environments International Conference (ReLIVE 08), 20-21 November 2008, The Open University, UK, pp. 200-207.

Macintosh, A., Filby, I. and Tate, A. (1998) “Knowledge Asset Road Maps”, Proceedings of The Second International Conference on Practical Aspects of Knowledge Management (PAKM98), (ed. U. Reimer) 29-30 October, 1998; Basel, Switzerland.
http://www.aiai.ed.ac.uk/project/oplan/documents/1998/98-pakm98-roadmaps.pdf

Malone, T. (1981) “Towards a Theory of Intrinsically Motivating Instruction”, Cognitive Science, Vol. 4 pp. 333-369.
http://www.coulthard.com/library/Files/malone_1981_towardtheoryintrinsicallymotivatinginstruction.pdf

Minocha, S. and Tingle, R. (2008) “Socialisation and Collaborative Learning of distance learners in 3-D Virtual Worlds”, in Proceedings of the Researching Learning in Virtual Environments International Conference (ReLIVE 08), 20-21 November 2008, The Open University, UK, pp. 200-207.

Minsky, M. (1985) “The Society of Mind”, Heinemann.

NASA (2012) “5Es Overview: The 5E instructional model”, NASA Education Web.
http://www.nasa.gov/audience/foreducators/nasaeclips/5eteachingmodels/

Norman, D.A. (2002) “The Design of Everyday Thing” (previously published as “The Psychology of Everyday Things”, 1988), Basic Books.

Norman, D.A. (2011) “Affordances and Design”, On-line Essay. http://www.jnd.org/dn.mss/affordances_and_design.html

Nwana, H.S. (1990) “Intelligent Tutoring Systems: An Overview”, Artificial Intelligence Review, Vol. 4, pp. 251-277.

OpenSimulator (2012) “OpenSimulator Virtual Worlds Server”, OpenSimulator Web Site. http://opensimulator.org/

OpenSimulator NPC (2012) “OpenSimulator Non-Player Character Functions”, OpenSimulator Wiki. http://opensimulator.org/wiki/OSSLNPC

O’Shea, T. and Self, J. (1983) “Learning and Teaching with Computers – Artificial Intelligence in Education”, Harvester Press.

Osinga, F. (2006) “Science Strategy and War. The Strategic Theory of John Boyd", Routledge: Abingdon, UK.

Pandorabots (2012) “Pandorabot ALICE Chatbots”. http://pandorabots.com

Papert, S.A. (1980) “Mindstorms: Children, Computers, and Powerful Ideas”, Basic Books. http://dl.acm.org/citation.cfm?id=1095592

Piaget, Jean (1954) “The Construction of Reality in the Child”, Routledge. Digital Edition 1999. http://books.google.co.uk/books?id=hK37xrpqdIkC

Pinker, S. (2003) “How the Mind Works”, New Edition, Penguin.

Plato (360 B.C.) “Laws”. Translation by Benjamin Jowett, Internet Classics Archive, 1994. http://classics.mit.edu/Plato/laws.html

Polyak, S.T. and Tate, A. (1998) “Rationale in Planning: Causality, Dependencies and Decisions”, Knowledge Engineering Review, Vol. 13. No. 1, pp. 247-262, March 1998.

Psychology Today (2011) “The Power of Stories - Telling Stories is the Best Way to Teach, Persuade, and Even Understand Ourselves”, June 2011, Sussex Publishers. http://www.psychologytoday.com/collections/201106/the-power-stories

ReLIVE (2008) “Proceedings of the Researching Learning in Virtual Environments International Conference” (ReLIVE 08), 20-21 November 2008, The Open University, UK.
http://www.open.ac.uk/relive08/catch-up.shtml (see Lo-Res and Hi-Res proceedings PDF)

Rheingold, Howard (1993) “The Virtual Community”, Internet Edition. http://www.rheingold.com/vc/book/

Robson, C. (2011) “Real World Research – a Resource for Users of Social Research Methods in Applied Settings”, 3rd Edition, John Wiley & Sons.

Sacerdoti, E. (1977) “A Structure for Plans and Behavior”, Artificial Intelligence Series, North Holland.

Scantlebury, N., McNulty, J. and Dowson, N. (2008) “Developing Sustainable Library Services within the Context of a Parallel Universe”, in Proceedings of the Researching Learning in Virtual Environments International Conference (ReLIVE 08), 20-21 November 2008, The Open University, UK, pp. 200-207.

Schank, R.C. and Abelson, R.P. (1977) “Scripts, Plans, Goals, and Understanding: An Inquiry into Human Knowledge Structures” (Artificial Intelligence Series) Psychology Press.

Selvin, A.M, Buckingham Shum, S.J., Sierhuis, M., Conklin, J., Zimmermann, B., Palus, C., Drath, W., Horth, D., Domingue, J., Motta, E. and Li, G. (2001) “Compendium: Making Meetings into Knowledge Events”, Knowledge Technologies 2001, Austin TX, USA, March 4-7, 2001.
http://www2.gca.org/knowledgetechnologies/2001/proceedings/Conklin&Selvin%20Slides.pdf

Sleeman, D. and Brown, J.S. (1982) “Intelligent Tutoring Systems”, Academic Press.

Steinkuehler, C. A. (2004) “Learning in Massively Multiplayer Online Games” in Y. B. Kafai, W. A. Sandoval, (eds. N. Enyedy, A.S. Nixon & F. Herrera), Proceedings of the Sixth International Conference of the Learning Sciences, pp. 521–528, Erlbaum.

Soller, A.L. (2001) “Supporting Social Interaction in an Intelligent Learning System”, International Journal of Artificial Intelligence in Education (IJAIED), Vol. 12, pp. 40-62. http://www.cscl-research.com/Dr/documents/ijaied/2001/Soller-IJAIED.html

Stevens, A., Collins, A. and Goldin, S. (1982) “Misconceptions in Student’s Understanding”, in (eds.) D. Sleeman, D. and J.S.Brown, “Intelligent Tutoring Systems”, pp. 13-24, Academic Press.

Suchman, L.A. (2007) “Human-Machine Reconfigurations: Plans and Situated Actions”, Cambridge University Press.

Tate (1993) “Notes towards the creation of a Programme Road Map”, AIAI, University of Edinburgh.
http://www.aiai.ed.ac.uk/~bat/roadmap.html
http://www.aiai.ed.ac.uk/~bat/roadmap-akt.ppt

Tate, A. (1996a) “Towards a Plan Ontology”, AI*IA Notiziqe (Quarterly Publication of the Associazione Italiana per l'Intelligenza Artificiale), Special Issue on "Aspects of Planning Research", Vol. 9. No. 1, pp. 19-26 - March 1996.
http://www.aiai.ed.ac.uk/project/oplan/documents/1996/96-aiia-plan-ontology.pdf

Tate, A., (1996b) “Representing Plans as a Set of Constraints - the <I-N-OVA> Model”, in Proceedings of the Third International Conference on Planning Systems (AIPS-96), Edinburgh, Scotland, May 1996, AAAI Press, pp. 221-228. http://www.aiai.ed.ac.uk/project/oplan/documents/1996/96-aips-inova.pdf

Tate, A. (1996c) “Smart Planning”, in “Advanced Planning Technology – Technological Achievements of the ARPA/Rome Laboratory Planning Initiative” (ed. Tate, A.), AAAI Press. http://www.aaai.org/Papers/ARPI/1996/ARPI96-000.pdf

Tate, A. (1998), “Roots of SPAR – Shared Planning and Activity Representation”, The Knowledge Engineering Review, Vol 13(1), pp. 121-128, Special Issue on Putting Ontologies to Use (eds. Uschold. M. and Tate, A.), Cambridge University Press, March 1998. http://www.aiai.ed.ac.uk/project/spar/DOCS/spar-roots.html

Tate, A. (2000) “Intelligible AI Planning”, in Research and Development in Intelligent Systems XVII, Proceedings of ES2000, The Twentieth British Computer Society Special Group on Expert Systems International Conference on Knowledge Based Systems and Applied Artificial Intelligence, pp. 3-16, Cambridge, UK, December 2000, Springer. With “Appendix: Comparing the Intelligible Planning Approach to Studies of Expert Human Planners - But I Don't Plan, I Just Know What to Do”. http://www.aiai.ed.ac.uk/project/ix/documents/2000/2000-sges-tate-intelligible-planning.pdf

Tate, A. (2003) “<I-N-C-A>: a Shared Model for Mixed-initiative Synthesis Tasks”, Proceedings of the Workshop on Mixed-Initiative Intelligent Systems (MIIS) at the International Joint Conference on Artificial Intelligence (IJCAI-03), pp. 125-130, Acapulco, Mexico, August 2003. http://www.aiai.ed.ac.uk/project/ix/documents/2003/2003-ijcai-miis-tate-inca.pdf

Tate, A. (2006) “The Helpful Environment: Geographically Dispersed Intelligent Agents That Collaborate”, Special Issue on "The Future of AI", IEEE Intelligent Systems, May-June 2006, Vol. 27, No. 3, pp 57-61. IEEE Computer Society http://www.aiai.ed.ac.uk/project/ix/documents/2006/2006-ieee-is-tate-helpful-env-as-published.pdf

Tate, A. (2011a) “I-Room: Augmenting Virtual Worlds with Intelligent Systems to Support Collaborative Decision Making”, Special Issue on "Virtual Worlds Architectures", IEEE Internet Computing, Vol. 15, No. 5, pp. 56-61, September-October 2011, IEEE Computer Society. http://www.aiai.ed.ac.uk/project/ix/documents/2011/2011-ieee-ic-tate-iroom-as-published.pdf

Tate, A. (2011b) “The Power of Stories”, Essay for Understanding Learning in an On-line Environment course as part of MSc in e-Learning, School of Education, University of Edinburgh, 7th December 2011. http://atate.org/mscel/assignments/ULOE11-Essay-Tate.pdf

Tate, A. (2011c) “Moodle/SLoodle Experiments Documented via Blog Entries on MSc in e-Learning 2011”, On-line weblog archive. http://atate.org/mscel/archive/Moodle-SLoodle-Experiments-Mscel-Blogs-2011.pdf

Tate, A. (2012) "Synoptic Essay for Introduction to Digital Game-Based Learning", as part of MSc in e-Learning, School of Education, University of Edinburgh, 11th April 2012. http://atate.org/mscel/assignments/IDGBL-Synoptic-Essay.pdf

Tate, A., Buckingham Shum, S.J., Dalton, J, Mancini, C. and Selvin, A.M. (2006) "Co-OPR: Design and Evaluation of Collaborative Sensemaking and Planning Tools for Personnel Recovery", Open University Knowledge Media Institute, Technical Report KMI-06-07, March 2006. http://kmi.open.ac.uk/publications/pdf/KMI-TR-06-07.pdf

Tate, A., Chen-Burger, Y-H., Dalton, J., Potter, S., Richardson, D., Stader, J., Wickler, G., Bankier, I., Walton, C. and Williams, P.G. (2010a) "I-Room: A Virtual Space for Intelligent Interaction", IEEE Intelligent Systems, Vol. 25, No. 4, pp. 62-71, July-August 2010, IEEE Computer Society. http://www.aiai.ed.ac.uk/project/ix/documents/2010/2010-ieee-is-tate-iroom-as-published.pdf

Tate, A., Chen Burger, Y-H., Dalton, J., Potter, S., Wickler, G., Carley, K.M., Kunkel, F., Cross, R., Hansberger, J.T. and Moon, B. (2010b), "Open Virtual Collaboration Environment for the Whole of Society Crisis Response Community", Proceedings of the Sixth International Conference on Knowledge Systems for Coalition Operations (KSCO-2010) (Lawton, J. (ed.)), Vancouver, B.C., Canada, September 21-23, 2010.

Traum, D., Rickel, J., Gratch, J. and Marsella, S. (2003) "Negotiation over Tasks in Hybrid Human-agent Teams for Simulation-based Training", in Proceedings of the Second International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS '03), ACM, New York, NY, USA. http://dl.acm.org/citation.cfm?id=860646

Turkle, S. (1995) "Life on the Screen: Identity in the Age of the Internet", Simon and Schuster, New York.

Uszok, A., Bradshaw, J.M., Jeffers, R., Tate, A. and Dalton, J. (2004) "Applying KAoS Services to Ensure Policy Compliance for Semantic Web Services Workflow Composition and Enactment", in Proceedings of the Third International Semantic Web Conference (ISWC2004), Hiroshima, Japan, 7-11 November 2004. Published as Lecture Notes in Computer Science, LNCS 3298, Springer.

Underwood J. and Luckin, R. (2011) "Themes and Trends in AIED Research, 2000 to 2010, A Report for the UK's TLRP Technology Enhanced Learning - AIED Theme", The London Knowledge Lab., May 2011. http://www.tel.ac.uk/personalisation/artificial-intelligence-in-education/themes-and-trends-in-aied-research-2000-to-2010/

Vera, A. H. and Simon, H. A. (1993) "Situated Action: a Symbolic Interpretation", Cognitive Science, Vol. 17, pp. 7-48.

Vicdan, H. and Ulusoy, E. (2008) "Symbolic and Experiential Consumption of Body in Virtual Worlds: from (Dis)Embodiment to Symembodiment", Journal of Virtual Worlds Research Vol. 1. No. 2, In Special Issue on "Virtual Worlds Research: Consumer Behavior in Virtual Worlds", November 2008. http://jvwresearch.org

Vygotsky, L. (1934) “Thought and Language” (aka “Thinking and Speaking”), MIT Press (published in English in 1962). Internet version and translation by Eugenia Hanfmann and Gertrude Vakar. http://www.marxists.org/archive/vygotsky/works/words/

Wenger, E. (1987) “Artificial intelligence and Tutoring Systems: Computational and Cognitive Approaches to the Communication of Knowledge”, Morgan Kaufmann.

Wenger, E. (1998) “Communities of Practice - Learning, Meaning, and Identity”, Cambridge University Press. See also http://www.ewenger.com/theory

Wexler, J. (2002) “Artificial Intelligence in Games: A look at the smarts behind Lionhead Studio’s ‘Black and White’ and here it can and will go in the future”. Term project written for Professor Chris Brown, CS242 – Artificial Intelligence, 7th May 2002. http://www.cs.rochester.edu/~brown/242/assts/termprojs/games.pdf

Wickler, G., Tate, A. and Hansberger, J.T. (2007) “Supporting Collaborative Operations within a Coalition Personnel Recovery Center”, Proceedings of the Fourth International Conference on Knowledge Systems for Coalition Operations (KSCO-2007) (Lawton, J., Patel, J. and Tate. A. eds.) pp. 14-19, Waltham, MA, USA, 1-2 May 2007. In Proceedings of the International Conference on Integration of Knowledge Intensive Multi-Agent Systems Modelling, Evolution and Engineering (KIMAS '07).

Wood, D., Bruner, J. S. and Ross, G. (1976) “The Role of Tutoring in Problem Solving”, Journal of Child Psychology and Psychiatry, Vol. 17, pp. 89–100. http://onlinelibrary.wiley.com/doi/10.1111/j.1469-7610.1976.tb00381.x/pdf

Zinn, C., Moore, J.D. and Core, M.G. (2002) “A 3-tier Planning Architecture for Managing Tutorial Dialogue”, Intelligent Tutoring Systems, Sixth International Conference (ITS 2002), Biarritz, France, June 2002. http://people.ict.usc.edu/~core/papers/its2002paper_n._002_final.pdf

Appendix A: OPERATIONS CENTRES IN REAL LIFE

This appendix provides further details of operations centres used for real emergency response purposes by members of the target learner communities, and physical training centres used for their training at present.

Civil and Business Emergency Response Coordination Centres

Civil agencies such as the Tokyo emergency response coordination centre and the associated Metropolitan Government briefing and decision making meeting room (Tate, 2006) and the Lothian Region Fire and Rescue Service control room (Han et al, 2010) have informed the requirements for the design of a virtual operations centre. The design has been refined in actual experimental use for scenario-based exercises with real emergency responders from civil and military organisations as part of the OpenVCE (Open Virtual Collaboration Environment) programme (Tate et al., 2010b).

Figure A.1: Typical Physical Emergency Response Coordination Centre – in this case, that for the Tokyo City and Tokyo Bay Area [Image from Tate (2006)]

Figure A.2: Typical Decision Makers’ Status Update and Briefing Meeting Space – Tokyo Metropolitan Government

Figure A.3: Typical layout of emergency response and crisis response centre as used by industrial and business organisations [Image from I-C2 Systems Ltd.]

The sorts of crisis response and business continuity centres used by industrial and commercial organisations often are simple rooms set up with screens, whiteboards, pin boards and communications equipment.

Mobile vehicles used by government civil agencies are also used as temporary crisis response coordination centres and to set up temporary communications in situations where physical infrastructure is damaged. Their interiors though are often similar to other office or collaborative meeting environments.

Figure A.4: Titan Corporation Emergency Response Vehicles as used by the US Federal Emergency Management Agency (FEMA)

Figure A.5: Interior of Titan Corporation Emergency Response Vehicles as used by the US Federal Emergency Management Agency (FEMA)

Future command and control operations centres have also been explored within the DARPA/US Air Force Research Labs. Planning Initiative (Tate, 1996c) and have influenced the design of the scenario-based virtual training environment.

Figure A.5: (D)ARPA/US Air Force Research Labs. Planning Initiative (ARPI) Visualisation of a Future Command and Control Operations Centre

Further Details of the PRETC, Frederickburg

The Personnel Recovery Education and Training Center (PRETC) based in Fredericksburg, Virginia for the training of US military and civilian personnel who will be engaged in Search and Rescue (SAR) and Personnel Recovery (PR) operations was described earlier. Further background and details are provided here.

The typical training rooms in the PRETC are office-like, or with tables around which the personnel gather for discussions. Computer screens surround the room along with whiteboards and notice boards on which important status information is maintained. Operations manuals are available. Much of the training stresses the importance of Standard Operating Procedures (SOPs) and related forms, and their careful use. Cross checking of information as it is communicated and transcribed onto boards is also a feature of the training. Appropriate use of communications equipment including computers, telephones, radios and faxes and even the careful and appropriate use of the waste bin (given security risks and the need for record keeping, later lessons learned analysis, etc.) are all made explicit through the provision of items in the training rooms.

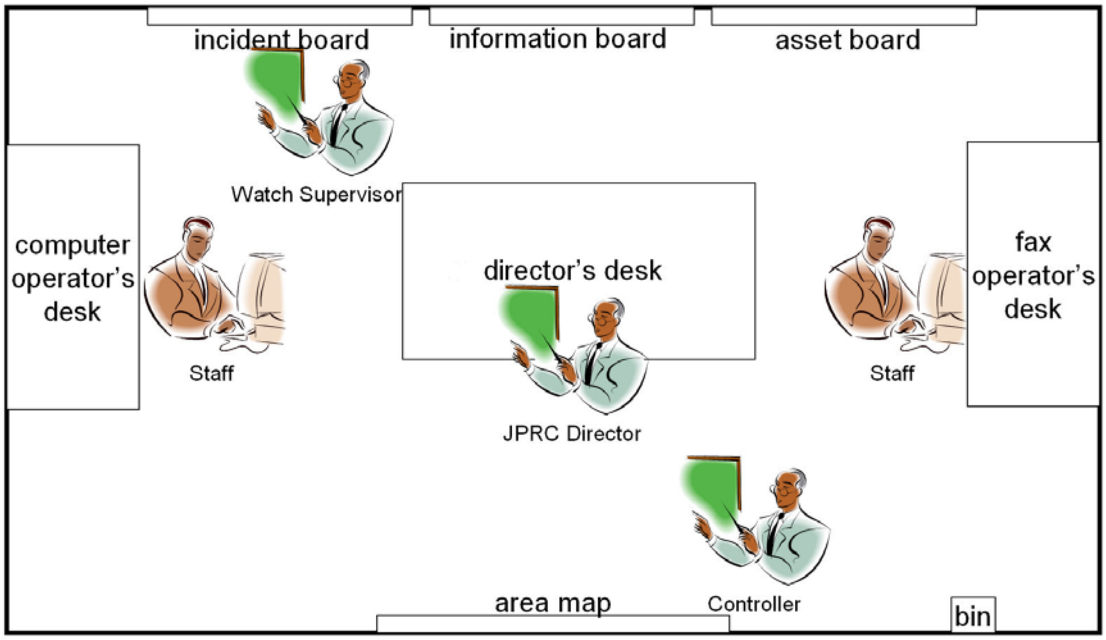

Figure A.6: Typical layout of Main SAR Coordination Centre at PRETC, Fredericksburg, Virginia

Figure A.7: The Author in a typical "pre-scenario" Search and Rescue Training Room with operational manuals, forms and whiteboards ready to go and studying the area map

Appendix B: Technology Exploration – Virtual Worlds Classroom Assistant = Virtual World NPC Avatar + Chatbot + Intelligent Agent

Virtual World Mechanisms for Autonomous Characters

A means to embody a classroom assistant in an in-world object needs to be available in virtual worlds such as Second Life (Linden Labs., 2012) and OpenSimulator (2012). There are several ways this can be done:

1. via a fully functional logged-in avatar (much like a normal user would use) via a virtual world "viewer";
2. via an in-world object, which could be some simple 3D object or designed to look more like an avatar;
3. via a Head-Up-Display (HUD) in the virtual world viewer which an individual trainee could attach or have attached for them when they enter a classroom; or
4. via an avatar-like Non-Player Character (NPC).

All would allow for various types of script execution, and via avatar or HUD "attachments" can be used to communicate with and move the avatar and object in world as needed. Scripted objects such as attachments or HUDs in virtual worlds like Second Life or OpenSimulator can listen to and write on text chat channels which can be seen by other users or by objects elsewhere in the environment, and which can respond accordingly.

Examples of Virtual Worlds Meeting Room Assistants

For work on the Open Virtual Collaboration Environment (OpenVCE.net) a number of "virtual world personalities" have been used to perform a variety of roles. Examples are:

- Skye Gears – Role: Support to Events and Meeting Attendees, Tutorials, FAQs, Voice Testing, etc. See http://openvce.net/skye-gears

- Aura Atlass and Mhor Atlass – Role: Maintenance of video and text chat links between Virtual World and other teleconference facilities such as Adobe Connect and Blackboard Collaborate. See, for example, http://openvce.net/aura-atlass

- I-Room Helper – Role: I-Room assistant, meeting text chat logging, avatar presence logging, I-X intelligent meeting support link, I-Room media control, etc. See http://openvce.net/iroom-helper

The role-playing characters have been embodied in normally logged in avatars which must have a human user, and are associated with that user's account. Only a single avatar can be logged in at any time for that account. Multiple points of presence cannot be supported with this mechanism, e.g., in multiple concurrent experiment or event spaces. Hence, Non-Player Character (NPC) technology has been explored to allow for such a role playing or meeting support avatar.

Figure B.1: Virtual Personalities: Skye Gears, Aura Atlass and Mhor Atlass

OpenSimulator NPC Avatar Technology

A set of OpenSimulator Functions (osFns) are provided to generate and manipulate NPCs. See http://opensimulator.org/wiki/OSSLNPC for more details of OpenSimulator NPC technology and functions. A set of NPC functions for the classroom assistant have been provided as templates for future work. These are attached below, and available at http://atate.org/mscel/i-zone/npc/

Chatbot Technology

Pandora bots based on the ALICE framework (Pandorabots, 2012) and MyCyberTwin chatbots (MyCyberTwin, 2012) as used on the Vue regions in Second Life and OpenSimulator have been explored to act as a knowledge communication and FAQ mechanism for the experimental AI classroom assistant.

Further information is available at:

- http://chatbots.org
- http://mycybertwin.com
- http://www.pandorabots.com/

MyCyberTwin Chatbot

http://mycybertwin.com
Ai Austin MyCyberTwin
https://mycybertwin.com/chat/aiaustin
useridnum=32285

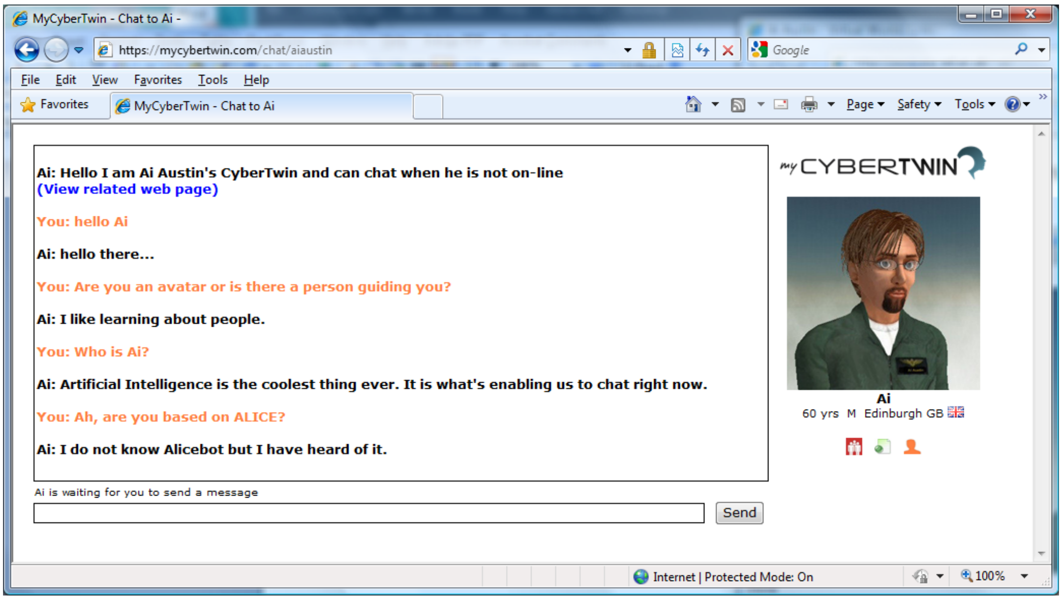

Figure B.2: Web Interface to MyCyberTwin Chatbot

Pandorabot AI Chatbot

http://pandorabots.com
Ai Austin Bot – based on Annotated ALICE -
http://www.pandorabots.com/pandora/talk?botid=a796a091be3426da

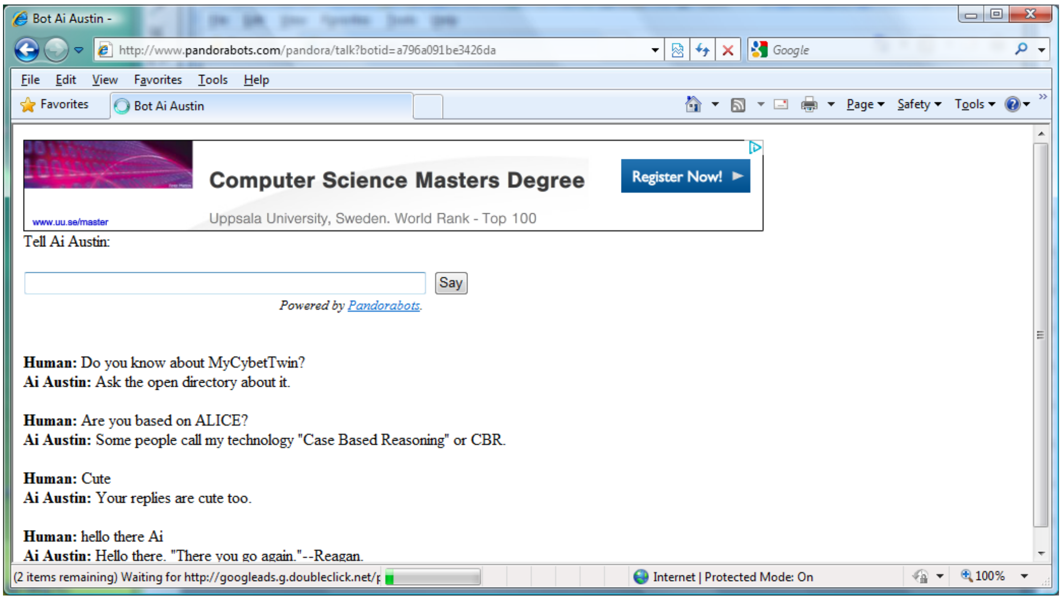

Figure B.3: Web Interface to Pandorabot AI Chatbot

Pandorabot Second Life/OpenSimulator Script

This open-source script is attached to this dissertation as it is a key component of the link up between Second Life/OpenSimulator and an external web-based tool such as a chatbot, in this example a Pandorabot based on ALICE.

```
///// PANDORABOTS AI CHAT SCRIPT /////
/////        By Zetaphor         /////
// 1) Create an account on Pandorabots.com
// 2) Create a new bot by following the instructions
// 3) Publish your bot
// 4) Take the botID from the URL, and replace the botid already here,
//    or just use the one provided!

string url;
string botid="a796a091be3426da";
list params;
integer brainon;

default
{
    state_entry()
    {
        llListen(0, "", NULL_KEY, "");
    }

    touch_start(integer total_number)
    {
        if (brainon==TRUE)
        {
            llSay(0,"AI Chatbot Disabled!");
            brainon=FALSE;
        }
        else
        {
            llSay(0,"AI Chatbot Enabled!");
            brainon=TRUE;
        }
    }

    listen(integer channel, string name, key id, string message)
    {
        if (brainon==TRUE)
        {
            string url="http://www.pandorabots.com/pandora/talk-
xml?botid="+botid+"&costid="+(string)llDetectedKey(0)+"&input="+llEscapeURL(message);
            llHTTPRequest(url,params,"");
        }
    }

    http_response(key request_id, integer status, list metadata, string body)
    {
        list response=llParseString2List(body,["<that>"],["</that>"]);
        llSay(0,llList2String(response,1));
    }

}
```

MyCyberTwin Second Life/OpenSimulator Script

MyCyberTwin have provided a script which allows for communications between an avatar attachment and the MyCyberTwin web portal at https://mycbertwin.com. It is approved for non-commercial use by those associated with the Virtual University of Edinburgh (Vue) and OpenVCE communities by the company and is available on request to Vue and OpenVCE.net community members via a.tate@ed.ac.uk. It can also be obtained at a small cost from MyCyberTwin.

I-X Technology and I-Room Helper Second Life/OpenSimulator Scripts

The current release of the I-X Intelligent Systems Technology is accessible at:

http://www.aiai.ed.ac.uk/project/ix/

A sample I-Room application for I-X Technology along with companion Second Life or OpenSimulator scripts for an in-world “I-X Helper” and related display screens are accessible at:

http://www.aiai.ed.ac.uk/project/i-room/

NPC OpenSimulator Scripts

These scripts allow for the creation, seating and removal of NPC clones in OpenSimulator. See http://opensimulator.org/wiki/OSSLNPC for more details of OpenSimulator NPC technology and functions.

NPC Creator (Owner Use Only)

```
// Example UUID of e24a9015-f5ca-452b-8c95-d32e34cb9d64 is
// "Ai Austin" on Openvue grid.

// touch to create npc in front of this emitter
// Npc will walk to the toucher, then will greet them.
// Touch again to remove the NPC

// http://opensimulator.org/wiki/OSSLNPC

// http://opensimulator.org/wiki/OsNpcCreate
// http://opensimulator.org/wiki/OsNpcRemove
// http://opensimulator.org/wiki/OsNpcMoveTo
// http://opensimulator.org/wiki/OsNpcSay

string npcNoteCard = "NPC Appearance";

key npc;
vector toucherPos;

default
{

    state_entry() {
        llSetText("NPC Creator (Owner Use Only)",<0.6,0.6,0.6>, 1.0);
    }
    touch_start(integer number)
    {
        vector npcPos = llGetPos() + <1,0,0>;

        llSay(0,(string)llDetectedKey(number));
        if (llDetectedKey(0) == llGetOwner()) {
            osAgentSaveAppearance(llDetectedKey(0), npcNoteCard);
            npc = osNpcCreate("Ai", "Tutor", npcPos, npcNoteCard);

            // below for specific logged in avatar cloning via UUID
            // npc = osNpcCreate("ImYour", "Clone", npcPos,
            //                   "e24a9015-f5ca-452b-8c95-d32e34cb9d64");

            // below for temp copy of NPC without saving appearance
            // npc = osNpcCreate("ImYour", "Clone", npcPos,
            //                   llGetOwnerKey(llGetKey()));

            toucherPos = llDetectedPos(0);
            state hasNPC;
        }
        else llSay(0,"Sorry, I only make NPCs for "+llKey2Name(llGetOwner())+
```

```
                    "\n You are "+llKey2Name(llDetectedKey(number)));
    }
}

state hasNPC
{
    state_entry()
    {
        osNpcMoveTo(npc, toucherPos + <3,0,0>); // land at a small offset

        osNpcSay(npc, "Hi there! My name is " + llKey2Name(npc));
    }

    touch_start(integer number)
    {
        osNpcSay(npc, "Good bye!");
        osNpcRemove(npc);
        npc = NULL_KEY;
        state default;
    }
}
```

NPC Sit and Stand

```
// osNpcSit(<npc-uuid>, <target-uuid>, OS_NPC_SIT_NOW)
//     e.g. osNpcSit(npc, llGetKey(), OS_NPC_SIT_NOW);
//     target object must have sit positon set explicitly
// osNpcStand(<npc-id>)

// touch to create npc in front of this emitter
// Npc will walk to the toucher, then will greet them.
// Touch again to remove the NPC

// http://opensimulator.org/wiki/OSSLNPC

// http://opensimulator.org/wiki/OsNpcCreate
// http://opensimulator.org/wiki/OsNpcRemove
// http://opensimulator.org/wiki/OsNpcMoveTo
// http://opensimulator.org/wiki/OsNpcSay

string npcNoteCard = "NPC Appearance";

key npc;
vector toucherPos;

default
{

    state_entry() {
        llSetText("NPC Sitdown (Owner Use Only)",<0.6,0.6,0.6>, 1.0);
    }
    touch_start(integer number)
    {
        vector npcPos = llGetPos() + <1,0,0>;

        llSay(0,(string)llDetectedKey(number));
        if (llDetectedKey(0) == llGetOwner()) {
            osAgentSaveAppearance(llDetectedKey(0), npcNoteCard);
            npc = osNpcCreate("Sitting", "Clone", npcPos, npcNoteCard);

            // below for specific logged in avatar cloning via UUID
            // npc = osNpcCreate("ImYour", "Clone", npcPos,
            //                   "e24a9015-f5ca-452b-8c95-d32e34cb9d64");

            // below or temp copy of NPC without saving appearance
            // npc = osNpcCreate("ImYour", "Clone", npcPos,
            //                   llGetOwnerKey(llGetKey()));

            toucherPos = llDetectedPos(0);
            state hasNPC;
        }
        else llSay(0,"Sorry, I only make NPCs for "+llKey2Name(llGetOwner())+
                    "\n You are "+llKey2Name(llDetectedKey(number)));
```

```
    }
}

state hasNPC
{
    state_entry()
    {
        osNpcSit(npc, llGetKey(), OS_NPC_SIT_NOW);
        // osNpcMoveTo(npc, toucherPos + <3,0,0>); // land at a small offset

        osNpcSay(npc, "Hi there! My name is " + llKey2Name(npc)+
                      " and I am sitting down.");
    }

    touch_start(integer number)
    {
        osNpcStand(npc);
        osNpcMoveTo(npc, toucherPos + <3,0,0>); // land at a small offset
        osNpcSay(npc, "Good bye!");
        osNpcRemove(npc);
        npc = NULL_KEY;
        state default;
    }
}
```

SetSitTarget

```
// Set typical seating position for 0.5m cube
default
{
    state_entry()
    {
        llSitTarget(<0.275,0.0,0.55>,ZERO_ROTATION);
    }

}
```

GiveObjectUUID

```
// Returns key (and linked number of part of a link set) of object script is in
// Can add to object to get UUID and then delete the script from object contents
// Can record UUID provided in object description for convenience.

default
{
    state_entry()
    {
        llOwnerSay(llGetKey());
        // llOwnerSay(llGetLinkKey(llGetLinkNumber()));
    }
}
```

NPC Remover - All NPCs in Region

```
// sim-wide NPC killer
// kill all of NPCs in this SIM
// Attempts to kill agents too, but it will silently fail
// http://opensimulator.org/wiki/OsNpcRemove

default
{
    touch_start(integer number)
    {
        list avatars = llList2ListStrided(osGetAvatarList(), 0, -1, 3);
        integer i;
        llSay(0,"NPC Removal: No avatars will be harmed or removed in this process!");
        for (i=0; i<llGetListLength(avatars); i++)
        {
            string target = llList2String(avatars, i);
```

```
            osNpcRemove(target);
            llSay(0,"NPC Removal: Target "+target);
        }
    }
}
```

NPC Remover - Named UUIDs

```
// NPC 001  key npc1 = "69d7ac2e-6574-44b0-8339-43703776e812";
// Jane Doe key npc2 = "0a81dda7-8296-4e69-99ae-11d9cdde4776";

key npc1 = "69d7ac2e-6574-44b0-8339-43703776e812";
// key npc2 = "0a81dda7-8296-4e69-99ae-11d9cdde4776";

 default
 {
     state_entry() {
     }

    touch_start(integer num_detected) {
        osNpcSay (npc1, "1: I am a goner!.....");
        osNpcRemove (npc1);
        // osNpcSay (npc2, "2: I am a goner!.....");
        // osNpcRemove (npc2);
    }

 }
```

NPC Persistence over OpenSim Restarts

```
// http://opensimulator.org/wiki/User:Marcus_Llewellyn/NPC_Scripts
// Marcus Llewellyn <marcus.llewellyn@gmail.com> 15-Oct-2011

// NPC Persistance Example created by Marcus Llewellyn.
// This script is in the Public Domain.

key npc = NULL_KEY;
string firstname = "Ai";
string lastname = "Austin";
integer dead = FALSE;

default
{
    state_entry() {
        // Setup and rez the NPC.
        key temp = (key)llGetObjectDesc();
        if (llKey2Name(temp) != "") {
            // An NPC matching the UUID stored in the object description
            // already exists, so just retrieve the UUID.
            npc = temp;
        } else if (dead == FALSE) {
            // Create a new instance of the NPC, record the UUID in the
            // object's description, and set starting rotation. NPC
            // rotation and location are inherited from the controlling
            // object with an offset.
            npc = osNpcCreate(firstname, lastname, llGetPos() + <1.0,0.0,0.0>,
                              llGetOwner());
            llSetObjectDesc((string)npc);
            osNpcSetRot(npc, llGetRot() * (llEuler2Rot(<0, 0, 90> * DEG_TO_RAD)));
        }
        // Have the NPC say a greeting, and set up persistance timer and
        // listen for commands.
        osNpcSay(npc, firstname + " " + lastname + ", at your service.");
        llSetTimerEvent(10);
        llListen(0, "", NULL_KEY, "");

    }

    timer() {
        // Our NPC UUID stored in the object description should match the
        // UUID of our existing NPC. If it does not, we presume an untimely
        // demise, and initiate resurrection by simply reseting our script.
        key temp = (key)llGetObjectDesc();
```

```
        if (llKey2Name(temp) == "" && dead == FALSE) {
            llResetScript();
        }
    }

    listen(integer channel, string name, key id, string msg) {
        if (llToLower(msg) == "kill") {
            // Kill the NPC, set a flag so it stays dead, and say something
appropriate
            osNpcSay(npc, "I am gone!");
            osNpcRemove(npc);
            dead = TRUE;
        } else if (llToLower(msg) == "start" && dead == TRUE) {
            // Create a new instance of our NPC, and set flag for
            // persistance checks.
            npc = osNpcCreate(firstname, lastname, llGetPos() + <1.0,0.0,0.0>,
                              llGetOwner());
            llSetObjectDesc((string)npc);
            osNpcSetRot(npc, llGetRot() * (llEuler2Rot(<0, 0, 90> * DEG_TO_RAD)));
            osNpcSay(npc, firstname + " " + lastname + ", at your service.");
            dead = FALSE;
        } else if (llToLower(msg) == "start" && dead == FALSE) {
            // Don't do anything significant if the NPC is still incarnate.
            osNpcSay(npc, "I'm already alive.");
        }
    }
}
```

Appendix C: MSC IN E-LEARNING DISSERTATION FESTIVAL 2012

Presentation by Ai Austin in Second Life to MSc in e-Learning Dissertation Festival 2012 on 1st August 2012.

Figure C.1: Ai Austin presenting to tutors, fellow class mates and visitors at the MSc in e-Learning Dissertation Festival 2012

Haiku:

Mixed-Initiative:
Constrain the environment,
Inject and Induce