Virtual Instructors:
An Investigation Of
Pedagogical Software Agents in Distance Learning

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A dissertation ***proposal draft*** submitted in partial fulfillment
of the requirements for the degree of
Doctor of Education
Department of Instructional Technology
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Last printed 1/13/03 2:53 PM

Chapter 1: Introduction

"Every time we teach a child something, we keep him from inventing it himself."
Jean Piaget

Abstract

Feyten (1991) suggests that listening is "central to all learning." Instructional messages (Fleming, & Levie 1993) of agent-based instruction, like that of most educators, are primarily through an auditory medium. Given this important component of agent-based instruction, a listening perspective should be considered. This proposed study then offers an investigation of agent-based instruction via a listening perspective.

1.0 An Introduction to the problem

Perhaps the best known agent is a fictional "character," the HAL 9000 computer from Arthur C. Clarke's *2001 : A Space Odyssey*. In this 1968 movie, HAL was a sophisticated computer system that could reason with humans and could autonomously perform actions on his surroundings (the spaceship - *Discovery*). Now imagine that HAL was programmed to teach Dave Bowman (an astronaut character on board with HAL). Then HAL would be an autonomous pedagogical software agent. Believe it or not, pedagogical software agents are among us already. Clippit®, the paperclip animation in Microsoft Word®, is an example of a common pedagogical agent.

Pedagogical agents tend to act as "Cognitive coaches." Through a cognitive apprenticeship model they can serve as experts that can teach (Tecuci, 1998). One might ask "But agents are software! How can they coach!?" Some of the most interesting social research is about this very subject. People tend to treat agents, and computers for that matter, as if they are humans (Reeves & Nass, 1996).

To better understand this phenomenon and how it relates to learning, Moreno et al. conducted a series of experiments in which they taught college students and 7th-graders how to design the roots, stem, and leaves of plants to survive in a variety of different environments through a multimedia lesson (Moreno et al., 2001). This multimedia lesson made use of an animated pedagogical agent named "Herman-the-bug."

Figure 1.1 – Herman the bug and the Design-A-Plant learning environment

Herman-the-bug uses verbal messages to "communicate" with students. His

instructional message (Fleming, & Levie 1993), like that of most instructors is through an auditory medium. Students learn by listening to Herman "speak." Agent-based instruction then is a form of listening-based instruction.

1.1 Purpose

Feyten (1991) suggests that listening is "central to all learning." Foreign language professionals have valued listening in instruction for decades. Agent-based instruction should then be looked at from a listening perspective, for this important component of communication may be closely associated with learning. But Mayer (2001) proposes that just one mode of instruction is less productive than two modes of instruction. This apparent contradiction will then serve as a basis of inquiry for this study. Therefore the purpose of this study is to investigate under what conditions, and especially, for whom, agent-based instruction can be effective.

1.2 Definitions

Active Server Pages (Abbr. ASP) - A scripting environment for Microsoft Internet Information Server in which you can combine HTML, scripts and reusable ActiveX server components to create dynamic web pages. IIS 4.0 includes scripting engines for Microsoft Visual Basic Scripting Edition (VBScript) and Microsoft Jscript (Microsoft's version of JavaScript). (Howe, 1993)

Hypertext - A term coined by Ted Nelson around 1965 for a collection of documents (or "nodes") containing cross-references or "links" which, with the aid of an interactive browser program, allow the reader to move easily from one document to another. (Howe, 1993)

Internet Information Server (IIS) - Microsoft's web server for Windows NT [and Windows 2000 server]. IIS is intended to meet the needs of a range of users: from workgroups and departments on a corporate intranet to ISPs hosting web sites that receive millions of hits per day. Features include innovative web publishing, customizable tools, wizards, customizable management tools, flexible administration options, and analysis tools. IIS makes it easy to share documents and information across a company intranet or the Internet, and is completely integrated with Windows NT Directory Services. (Howe, 1993)

JavaScript – also known as ECMAScript (European Computer Manufacturers Association Script) - The programming language defined by the ECMA-262 standard [ECMAScript - http://www.ecma.ch/ecma1/STAND/ECMA-262.HTM]. As stated in the standard, the originating technology for ECMAScript was JavaScript [Netscape Communications Corporation. – http://www.netscape.com or http://developer.netscape.com/docs/manuals/communicator/jsguide4/index.htm]. Note that in the ECMAScript Language binding, the word "property" is used in the same sense as the IDL term "attribute." (W3C, 2002)
- (Formerly known as LiveScript) Netscape's simple, cross-platform, World-Wide Web

scripting language, only very vaguely related to Java. JavaScript is intimately tied to the World-Wide Web, and currently runs in only three environments - as a server-side scripting language, as an embedded language in server-parsed HTML, and as an embedded language run in browsers. (Howe, 1993)

WebCT (Web Course Tools) – an online course management system for developing and delivering Web-based or Web-enhanced courses or instruction.

Web-enhanced instruction - With Web-enhanced instruction the instructor creates a web page (or pages) with relevant links for the class. Web-enhanced instruction is generally designed as a supplement to on-campus/on-site instruction. (Barron, 1998)

Web-based instruction - A hypermedia-based instructional program which utilizes the attributes and resources of the World Wide Web to create a meaningful learning environment where learning is fostered and supported. (Khan, 1997)

World Wide Web (Abbr. WWW) - n (1992) : a part of the Internet designed to allow easier navigation through the use of graphical user interfaces and hypertext links between different addresses – called also *Web* (Merriam-Webster, Incorporated, 2001).

Visual Basic Scripting language (Abbr. VBScript) - Microsoft's scripting language which is an extension of their Visual Basic language. VBScript can be used with Microsoft Office applications and others. It can also be embedded in web pages but can only be understood by Internet Explorer. (Howe, 1993)

Chapter 2: A Literature Review

Unless one does it for one's self, it isn't thinking.
John Dewey - Democracy and Education, 1916

2.0 An Introduction

There are three main purposes of this chapter. One it describes what research has been accomplished to date in the various domains of this project. Secondly it also explains to the reader why the specific research questions were chosen (these are described in section 2.8). And finally a literature review provides a basis of exploration for the researcher.

2.1 Instructional Technology, Philosophy, and Science

From a historical perspective, Instructional Technology has undergone a dramatic change since its inception in the early 20th century (DeVaney & Butler, 1996). This dramatic change has been in part due to a shift in philosophical perspective.

In the 1930's and 1940's the philosophy of many educators focused on positivism (DeVaney & Butler, 1996). But in opposition to positivism, the past half century has seen the social sciences shift increasingly toward relativism. Education has not been an exception in this shift. Somewhat late in the game, educators began to embrace constructivism in the 1990's (Reiser, 2001). This was not only as a way to implement instruction, but in doing so they were beginning to choose relativism as an epistemological perspective. With this epistemological shift, there has been an associated shift in research practices from quantitative studies to qualitative and mixed designs (Savenye & Robinson, 1996).

In the early twentieth century the question on many an educators mind is "can positivism and constructivism coexist?" It is quite possible for these two philosophic perspectives to coexist. There may be a very structured clockwork universe as described by the positivists. But human minds do not have to be logical and structured to describe a structured universe. We can be very relativistic from a mental perspective and yet live and breathe in a very clockwork structured universe. Our conceptions from within of the outer world could be very relativistic. But that doesn't mean our universe has to be relativistic like us.

On the other hand we could be very complex and perceive ourselves to be relativistic when in fact we may follow very complex rules. These will continue to be the two perspectives of the early 21st century, as they have been for the last half century. But as relativists protest positivism and debate postmodernism, the positivists will continue to build on their previous work. Eventually a biological perspective of human motives will begin to evolve and the relativists will fall by the wayside. Such is the logic of science.

The above prose of logic quite handily explains the universe and constructivism, but it does not explain why educators should consider science seriously. Richard Mayer (2000) answers that question in a convincing article entitled "What is the place of science in educational research?" Mayer's article came as a result of several other articles in the Educational Researcher which suggested Science should not be the pursuit of educators.

Mayer quite handily dispatched such notions by giving two reasons why educators should consider science seriously:

1. To maintain self-correcting progress for educational theory.
2. To maintain the reputation of educational research

As mentioned above postmodernists may debate *ad infinitum* about what exactly Postmodernism is; but Science will continue plodding forward as relativism runs in circles. This is because science is self correcting. Science may stray from its path being detour momentarily by incorrect assertions, but eventually it straightens its path and continues forward. This is the main failing of relativism.

Mayer's second reason is of less consequence and would only serve to provoke a postmodernist. But how education is perceived by others should be of some concern to educators. However unfortunate as it might be, this is because in our current society funding only finds its way in to the hands of those who are perceived to be deserving.

In addition to the above perspective, Mayer (2000) describes why so many researchers may question science in the first place. Unfortunately it may be because of a misconception. Science all too often is perceived as being quantitative and not qualitative. This is not the case.

As Mayer (2000) describes, some "scientists" may abuse quantitative studies in the pursuit of non-scientific goals. The same of course may hold for qualitative studies, but most qualitative researchers do pursue scientific studies and produce scientific results. Therefore educators should not think of qualitative studies as non-scientific.

2.1.1 Psychological Perspectives & Agents

The above discussion describes the primary researcher's perspective of science. But the world of science is not exactly black and white. Take for instance how one might perceive pedagogical agents based upon one's psychological perspective. Behaviorists tend to think of agents as Electronic Performance Support Systems (EPSSs) (Gery, 1991). A Cognitivist on the other hand may see pedagogical agents as cognitive tools (Baylor, 1999b). In many instances Pedagogical Agents can be both. Therefore the Instructional Designers of Pedagogical Agents fall some where on a continuum between the two perspectives.

Jonassen (1992) diagrams the above continuum with "Radical" Behaviorism and "Radical" Constructivism on the very extremes. Piagetian theory, Instructional Design,

and Programmed instruction fall between the two extreme views. Most instructors perspectives fall somewhere in the middle as well.

Cognitivism and Behaviorism were two important perspectives in the 20th century. This situation has begun to change somewhat. But before describing the current situation in Cognitive Science, a review of the Clark/Kozma debate is in order. This discussion will add perspective for Instructional Designers, and place this debate historically, relative to the psychological battles of Cognitivism/Behaviorism.

2.1.2 The Clark/Kozma Debate

In 1983, Richard E. Clark awoke the Instructional Design community with his paper *Reconsidering Research on Learning from Media*. It was in this paper that he argued that media "do not influence learning under any conditions" and are "mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes change in our nutrition." These were not unfounded statements for he had a great deal of corroborating evidence to support his argument. A number of media comparison studies had shown that there was not a significant difference between media being compared. Some of the most noteworthy evidence came from a meta-study of over forty audio-tutorial instruction studies (Kulik, Kulik, & Cohen,1980).

Clark contends that in those studies that do show achievement gains, that:

> *The most common sources of confounding in media research seem to be the uncontrolled effects of (a) instructional method or content differences between treatments that are compared, and (b) a novelty effect for newer media, which tends to disappear over time. (Clark, 1983)*

Clark then believes that more often than not the difference being measured is due to the instructional methods, rather than the media being compared. Clark then called for researchers to "refrain from producing additional studies exploring the relationship between media and learning unless a novel theory is suggested."

Unfortunately many researchers saw Clark's statements as a challenge to find proof of a statistical difference between the uses of different media. Media comparison studies continue even to this day.

In 1991, Robert Kozma wrote a rebuttal to Clark by providing a new cognitive theory of media. Kozma's new theory was from a cognitive perspective. This new cognitive theory of media proposed individuals strategically construct their knowledge from their perceptions of the world. "Learning from media," the behaviorist perspective is then reinterpreted from a cognitive perspective and becomes "Learning with media" (Kozma, 1991).

It called upon the attributes of various forms of media and how they might aid the learner during the learning process. For instance he argued that books offer the reader "stability" and the ability to review over material.

Kozma's Cognitive Theory although somewhat plausible, unsettled the Instructional Design Community yet again. For those against Clark's "instructional vehicle" analogy it served as a theoretical basis for their arguments. Thus a true debate in the Instructional Design Community was begun.

In 1994, Kozma wrote yet another article for ETR&D. Kozma offered this new article to the editorial staff with the comment that perhaps Clark should respond to this new article. Clark obliged. But in addition to the two articles by Clark and Kozma the editorial staff and reviewers of ETR&D decided to comment (Ross, 1994). The result was an entire issue devoted to the topic.

In Clark's 1994, article entitled *Media will never influence learning*, Clark reiterated many of his previous arguments but with an additional line of reasoning:

> *"…a number of very different media attributes served the same or similar cognitive functions. ...If there is no single media attribute that serves a unique cognitive effect for some learning task, then the attributes must be proxies for some other variables that are instrumental in learning gains (Clark, 1994)."*

This was the basis for his "Replaceablity challenge":

> *"I challenge Robert Kozma and other colleagues in this area to find evidence, in a well designed study, of any instance of a medium or media attributes that are not replaceable by a different set of media and attributes to achieve similar learning results for any given student and learning task (Clark, 1994)."*

Reiser was quick to respond to this challenge with the following:

> *"My reaction to this challenge is that it is stacked against anyone who attempts to under take it. Why? Because as an instructional designer I've found that regardless of how effective a particular instructional treatment might be, with enough effort, someone can usually design another treatment that is equally as effective (Reiser,1994 p. 46)."*

In addition he added:

> *"I feel that while Clark is correct in stating that methods are what cause learning to occur, he fails to acknowledge the fact that certain media attributes make certain methods possible (Reiser, 1994 p.45)."*

Finally, Jonassen et al. (1994) replied to both Clark and Kozma, with an argument that resounded through the Instructional Design community. This argument was that debating these issues was generally irrelevant and that:

> *"We believe that this debate should focus less on the characteristics and attributes of media for conveying knowledge and more on the attributes of the human learner involved in learning and ultimately the construction of knowledge (Jonassen et al., 1994 p.31)."*

It was in this way that the debate was "restructured." This debate had gone on to long and for the wrong reasons. Instructional Technologists had battled over media and method and forgotten what was most important – learning.

Eventually, Psychologist Richard Mayer wrote an article entitled *Multimedia learning: Are We Asking the Right Questions?* Mayer concludes that:

> *"Instructional development is too often based on what computers can do, rather than on a research theory of how students learn with technology (Mayer, 1997 p.17)."*

It was in this same article that Mayer described a Generative Theory of Multimedia. This theory will be fully discussed in the next section of this paper. But first a comprehensive look at Cognitive Science is an important first step.

2.2 Cognitive Science

Gardner (1985) cites 1956 as the year Cognitive Science was born. Why this year? This year marked the beginning of the Cognitive Revolution and Cognitive Science because this was the year a Symposium on Information Theory was held at the Massachusetts Institute of Technology (MIT) (Gardner, 1985). Psychologist George Miller sums it this way:

> *I went away from the Symposium with a strong conviction, more intuitive than rational, that human experimental psychology, theoretical linguistics, and computer simulation of cognitive processes were all pieces of a larger whole, and that the future would see progressive elaboration and coordination of their shared concerns (Miller, 1979 as cited in Gardner, 1985 p. 29).*

Cognitive Science, as this brief summary suggests is not just Cognitive Psychology. As this symposium showed the world there is a new interdisciplinary field marked by the coming together of several other disciplines. This new field is marked by the convening interests of Psychologist, Linguists, Computer Scientists, Philosophers, Anthropologists, and Neuroscientists (Gardner, 1985).

Even though Gardner did not mention Education when considering Cognitive Science, Education plays a central role for Education is a practical application of Cognitive theory.

Interestingly enough, 1956 was also a good year for the Cognitivists in Education. This is the year that Benjamin Bloom published his controversial Taxonomy of Educational Objectives, Handbook I, Cognitive Domain. This book allowed educators to think about the cognitive domain.

Cognitive Psychology and Instructional Design has benefited tremendously by this Revolution. In its simplest terms Psychology has gain a whole new way of looking at the human brain and cognitive processes. This new way is an Information Processing model. There is now an assumption that the brain and thus the mind is like an information processor (Dawson, 1998). So like our silicon counterparts - the computers, we too take in input from the environment and process this information. As we process this information we act upon our environment with our behavior (output).

2.2.1 Current Cognitive Theory

It was mentioned earlier that in 1997, Mayer developed a Generative Theory of Multimedia. This Generative Theory of Multimedia later developed into what he called a "Cognitive Theory of Multimedia Learning (Mayer & Moreno, 1998) (Note the diagram below)." This new cognitive theory of learning with multimedia relies heavily on previous theoretical works, especially that of Baddley, Pavio, Sweller, and Witrock (Mayer, 2001). As Mayer describes it in his 2001 book *Multimedia Learning* this theory relies on three assumptions; the dual channel assumption, a limited-capacity assumption, and an active processing assumption.

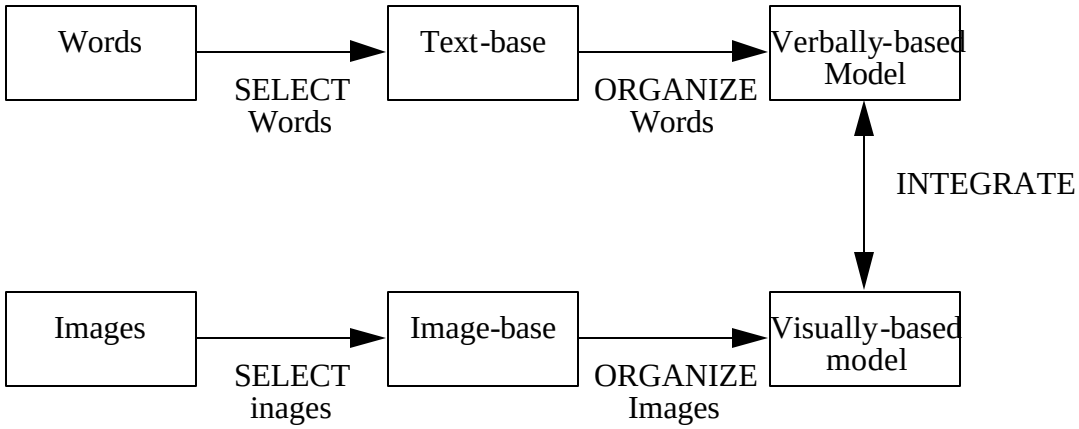

Figure 2.1 Mayer's cognitive model of multimedia learning.

This theory relies on three important mental processes, selection, organization and integration. The learner actively selects words and verbal messages to be stored in working memory. This learner also can simultaneously store pictures or animations as visual representations in a separate mode of working memory. Once in the learners working memory, the learner must organize that material in some way. Finally these two types memory can then be then integrated to form a verbal/visual model (Mayer & Moreno, 1998).

Multimedia Learning then occurs as a combination of media sources (most often auditory and visual – although other modalities exist as well) (Mayer, 2001). Instructional designers then should design instructional materials that convey instructional messages in the way that the brain works, by using both visual and verbal modes effectively (Mayer, 2001).

Mayer outlines several principles in his theory of multimedia learning. The first and most important to this study is his multimedia principle of learning. That is the use of just one mode is less productive than using two modes (Mayer, 2001). People can listen to a verbal message and view visual media simultaneously. This more efficient way of multimedia learning has proven to be a more effective way of providing instruction (Mayer, 2001).

2.3 Agents

Consider the following definition from the Merriam-Webster's Collegiate Dictionary:

> agent (ā'jənt)– from the Greek *agein* to drive, lead
> 1 : one that acts or exerts power
> 2 a : something that produces or is capable of producing an effect : an active or efficient cause b : a chemically, physically, or biologically active principle
> 3 : a means or instrument by which a guiding intelligence achieves a result
> 4 : one who is authorized to act for or in the place of another: as a : a representative, emissary, or official of a government

This definition leaves much up to interpretation (in particular, notice the fourth listing above). Most software could be said to act "for or in the place of another."

Defining agents was for several years controversial and in many cases based on hype (Nwana, 1996). Franklin and Graesser's 1997 paper, "Is It an Agent, or Just a Program?: A Taxonomy for Autonomous Agents," brought some clarity to the situation. In this paper they explained several well-known definitions of agents -- usually defined by those with a bias toward an agent that they personally had developed. This paper then generated a broad definition for agents based upon several important characteristics. As they described it, an autonomous agent is "a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future."

In considering the above definition it's important to notice that definition can apply to humans as well. Humans are situated in, and are a part of an environment. They sense their environment over time, in pursuit of their own agenda and so as to affect what they sense in the future. In Franklin & Graesser's words "An agent need not be a program at all; it may be a robot or a school teacher (Franklin & Graesser, 1997)."

Like Carl von Linné (a.k.a. Linnaeus), the 18th century botanist who founded taxonomy, Franklin & Grasser have developed a simple taxonomy of agents and suggest several possible methods of classifying agents (Note figure 2.2 below).

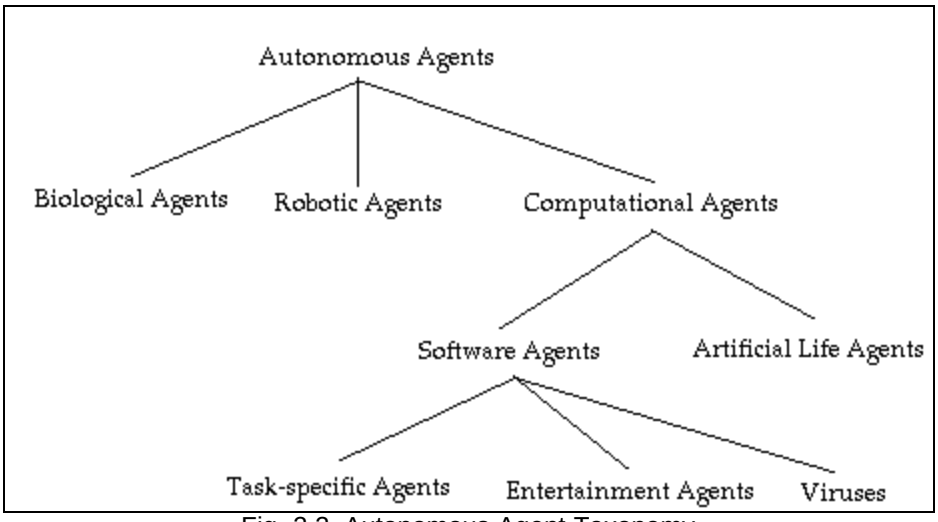

Fig. 2.2. Autonomous Agent Taxonomy
Source (Franklin & Graesser, 1997)

The classifications in Figure 2.2 are more for convenience sake than anything. Ideally by classifying agents into subcategories one could produce a nomenclature of agents that would allow researchers to discuss and research agents unambiguously (Franklin & Graesser, 1997). However this classification scheme is for an ideal situation. Darwin even suggested in his continuity of species thesis that our species designations for animals is largely for our convenience and quite arbitrary (Darwin, 1998).

Franklin and Graesser then suggest that we make distinctions between agents, based upon agent characteristics (Franklin & Graesser, 1997). Because this study is largely confined to software agents it will be necessary to confine the discussion of agent characteristics to those held by software.

2.4 Software Agents

Software agents have several specific characteristics that set them apart from other types of software. Agency implies that an agent may be: intelligent, embodied, trainable, may communicate, and may have some degree of autonomy.

2.4.1 Embodiment

Many agents have the characteristic of embodiment (Dix et al, 1998). That is the agent may have a physical or virtual body. A distinction should be made at this point. Avatars are a virtual representation of a person in a virtual environment (Çapin et al., 1999). An Avatar is under the control of a person. This is as opposed to an agent, which is autonomous or semiautonomous. A virtual body then does not imply agency. But agency may be embodied.

A production line robot is an example of an agent that has a physical body. Clippit® on the other hand has a virtual body. That is there is a digital representation of Clippit® within Windows®. This is as opposed to a disembodied agent that has no representation at all, but is an integrated portion of a program or environment that work's on your behalf (Dix et al, 1998). Web crawler programs, that travel the Internet to retrieve information for search engines, are examples of common disembodied agents (Dix et al, 1998).

2.4.2 Intelligence

Intelligence is an ambiguous term. AI researchers have been pondering over this one for several decades. Suffice it to say that intelligence is not an either/or phenomenon. In other words, one should not say that an agent is either intelligent or not (Franklin, 1995). Franklin argues that there is a continuum of intelligence (Franklin, 1995).

To demonstrate this continuum let's ask a few questions of the reader. If one were asked the question "is a bacterium intelligent?" Most would answer with a resounding "no!" But in defense of the underrepresented bacterium, it does carry out certain self-guided somewhat intelligent behaviors. It searches for food. It feeds itself. It reproduces. Granted bacteria are not nearly as intelligent as humans, but what about other mammals, say chimpanzees for instance. Some people would answer the question "are chimpanzees intelligent?" with the answer "yes."

Jane Goodall has even noted that chimpanzees make and use tools. They engage in what she calls "termite fishing," by stripping branches of their leaves and then by poking these sticks (their forks, if you will) into a nest of termites and then gain a meal (Goodall, 1971). Many have described tool usage as a sign of intelligence. But chimpanzees are not the only animals that use tools. One of Darwin's Finches, the Woodpecker Finch uses a similar technique. They dig out wood boring insects with a cactus spine (Lack, 1947).

Many people can attest to the intelligent behavior of cats or dogs. But they are not as intelligent as people of course. Isn't there then a continuum of intelligence? Dogs and cats are somewhat less intelligent than people, but obviously more intelligent than bacteria. Given this argument, agents then do not have to be as intelligent as humans to be called intelligent. They may even be less intelligent than the above-mentioned bacterium, but isn't the door left open then for agents to lie on the continuum of intelligence?

2.4.2.1 The Turing Test

An early definition of Intelligence was proposed over 50 years ago. The "Turing Test" as it came to be called, was first described by Alan M. Turing (1912-1954) as "the imitation game" in his 1950 article in *Computing Machinery and Intelligence*. In this historical article Turing suggested that a computer program may eventually be written that would be able to fool a human into believing that it is human. This test as it seems is easier to pass than many anticipated. This will be discussed later in this chapter under the heading of Social Aspects of Computing.

In 1990, a New York Philanthropist, Dr. Hugh Loebner, joined with The Cambridge Center for Behavioral Studies, to fund a contest designed to implement the Turing Test (Loebner, 2002). Dr. Loebner pledged a Grand Prize of $100,000(US) and a Gold Medal to the developer of the first computer whose responses were indistinguishable from a human's as described by Dr. Turing's 1950 article (A 50:50 likelihood of being mistaken for a human) (Loebner, 2002). However, Loebner added the additional challenge of audio-visual representations to Turing's original description of a text messaging computer. A Silver Prize of $25,000 is available for those able to achieve a 50:50 likelihood of being mistaken in a text-only mode. Finally there is a Bronze Prize of $2000 awarded annually to the computer program rated most human by a panel of judges (Loebner, 2002).

The 2000 and 2001 Bronze awards were awarded to a system called A.L.I.C.E. (Alicebot, 2002). A.L.I.C.E. was originally designed and developed in 1995 by Dr. Richard S. Wallace (Alicebot, 2002). A.L.I.C.E. makes use of an HTML-like Artificial Intelligence Markup Language known as AIML. Alicebot and AIML are distributed for free to schools, research labs and non-profit groups around the world (Alicebot, 2002).

2.4.3 Trainable agents

Agents can be trained in much the same way as humans (Maes, 1994). They must be able "to explore, to plan, to experiment, to adapt, and to discover (Shen, 1994)." Maes describes several agents that use a technique known as "Memory-Based Reasoning (Maes, 1994)." When using "Memory-Based Reasoning," the agent constantly "looks over the shoulder" of the user, as a user performs actions (Maes, 1994). By observing a user an agent builds up a "memory" of example user actions. When a new situation occurs the agent tries to predict the actions of the user. These memorized situations are then analyzed by performing correlations on the current situation and actions taken earlier by the user. Eventually when an agent feels "confident" enough, it will act. It may suggest an action to the user or simply act on its own (Lieberman, 1997). The user can at this point provide feedback (either positive or negative) to the agent and guide the agent's learning.

2.4.4 Communication

Agents may communicate with one another (this can include biological agents – i.e. humans) (Franklin & Graesser, 1997). This is known as "inter-agent communication." Many people may have communicated with an agent and not known it. A common example of inter-agent communication is when an agent emails a human to inform them that their email was not received. This automated system is performed by an "error delivery agent (Costales, 1993)."

In addition to inter-agent communication with humans, software agents can communicate with one another. The main reason for this is so they may collaborate with one another to accomplish a predetermined goal (Finin et al., 1992). Software agents use a language known as Knowledge Query and Manipulation Language (Finin et al., 1997). This

language is somewhat similar to SQL (Structured Query Language). KQML is a language and the associated protocol can be use as a means of communication between agents or other software programs (Finin et al., 1992). Finally agents can “speak” in English, to communicate with humans via Synthetic Speech.

2.4.4.1 Synthetic Speech

For many people, the idea of synthetic speech generates visions of Stephen Hawking. Stephen Hawking is a brilliant British theoretical physicist, that has a progressive neurological disease known as amyotrophic lateral sclerosis, or “Lou Gehrig’s Disease” (PBSonline, n.d.). Because of this disease, he spends his life in a wheel chair and having had a tracheotomy, he has lost the use of his voice (Filkin, 1997). Speech synthesis has enabled him to continue his work as the Lucasian Professor of Mathematics at Cambridge University, a position once held by Isaac Newton (PBS, n.d.). He is able to produce meaningful sentences by tiny movements of his thumb and forefinger on a pressure pad (Filkin, 1997). It is in this way he can thumb through a database of words and string together meaningful phrases, that are uttered through a speech synthesis software known as DECtalk (Paciello, 2001). But DECtalk was developed in 1983 (Klatt, 1987).

Speech synthesis or text-to-speech software rather, has undergone tremendous development since the early 1980’s. Through a New York Times press release last July, AT&T Labs announced that it has produced software that is capable of copying any human voice. In their words it “is so good at reproducing the sounds, inflections and intonations of a human voice that it can recreate voices and even bring the voices of long-dead celebrities back to life (Guernsey, 2001).”

This text-to-speech software, in a somewhat limited form, is now even available to instructional designers for less than $50. This software enables an Instructional designer to give a software agent a near human voice. Also because it is text-based speech, it is possible for a computer to dynamically produce speech using this text-to-speech engine. Speech and communication are at the heart of instruction. There for instructional designers should not only investigate this new technology, but also study the implications it may have for instructional design. This form of adaptive instruction with a social interface may prove useful to distance learning for instance. Because distance learners must learn at a distance, learners tend to feel isolated when unable to talk to the instructor or there peers (Galusha, 1997). Perhaps software agents may lessen or alleviate this phenomenon.

2.4.5 Autonomy

Autonomy like intelligence is another ill-defined concept (Luck & d'Inverno, 1995). According to Lieberman, an autonomous agent is an agent "that takes action without user intervention and operates concurrently, either while the user is idle or taking other actions (Lieberman, 1997)." An agent then, may very well be autonomous, but respond to a user and act in accordance to its programming.

Luck & d'Inverno use an entity hierarchy to describe the differences between objects, agents, and autonomous agents (Note Figure 2.3).

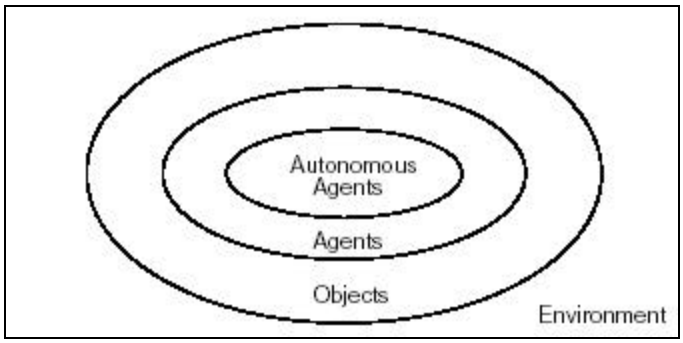

Fig. 2.3. The Entity Hierarchy
Source (Luck & d'Inverno, 1995)

Franklin and Graesser's definition was of autonomous agents, but obviously not all agents are autonomous. The above diagram shows sharp dividing lines separating each type of entity, but as Franklin & Graesser mention in their now classic paper:

> *The only concepts that yield sharp edge categories are mathematical concepts, and they succeed only because they are content free. Agents "live" in the real world (or some world), and real world concepts yield fuzzy categories. (Franklin & Graesser, 1997)*

Therefore the lines between each of these categories are in a sense fuzzy. An important point that both Franklin & Graesser, and Luck & d'Inverno make is that all agents must exist in some environment. Software agents must "live" in an operating system or on the internet for instance. Turn the computer off and the agent may be lost. Before the reader begins to feel too superior, this rule applies to humans as well. Remove a human's comfortable earthly environment by jettisoning that human into interstellar space, and the human could also be lost.

Autonomy then, is relative to an environment. Agents operate relative to environmental cues from the environment in which they exist. These cues could originate from the environment itself, another agent or even a user. A real world example of an agent that accepts cues from the environment is a thermostat (Franklin & Graesser, 1997). This common example's sole purpose is to wait until an environmental cue – the temperature rises or falls below a pre-specified temperature -- and then it performs its preprogrammed task.

Agents can also accept cues from other agents. When agents work together in this manner they are working as a multi-agent system. They can "communicate" with other agents to perform some action. Foner describes a prototype "Matchmaking" system which makes use of user preferences to find other similar users and introduce them to one another (Foner, 1996). The use Foner describes for this system is to introduce people working on similar projects. Rather than "redesigning the wheel" independently, these users could be introduced and then be able to work collaboratively.

Finally, for the case in which an agent responds to a user, the user would of course have to alter an agent's environment or submit commands directly to the agent through a human computer interface (for example the Windows® operating system). An interface agent then operates in a Human Computer Interface.

2.5 Pedagogical Agents

2.5.1 "Herman-the-bug"

The literature shows that several pedagogical agents have been developed. "Herman-the-bug" is perhaps one of the most studied pedagogical agents (shown below in Figure 2.4).

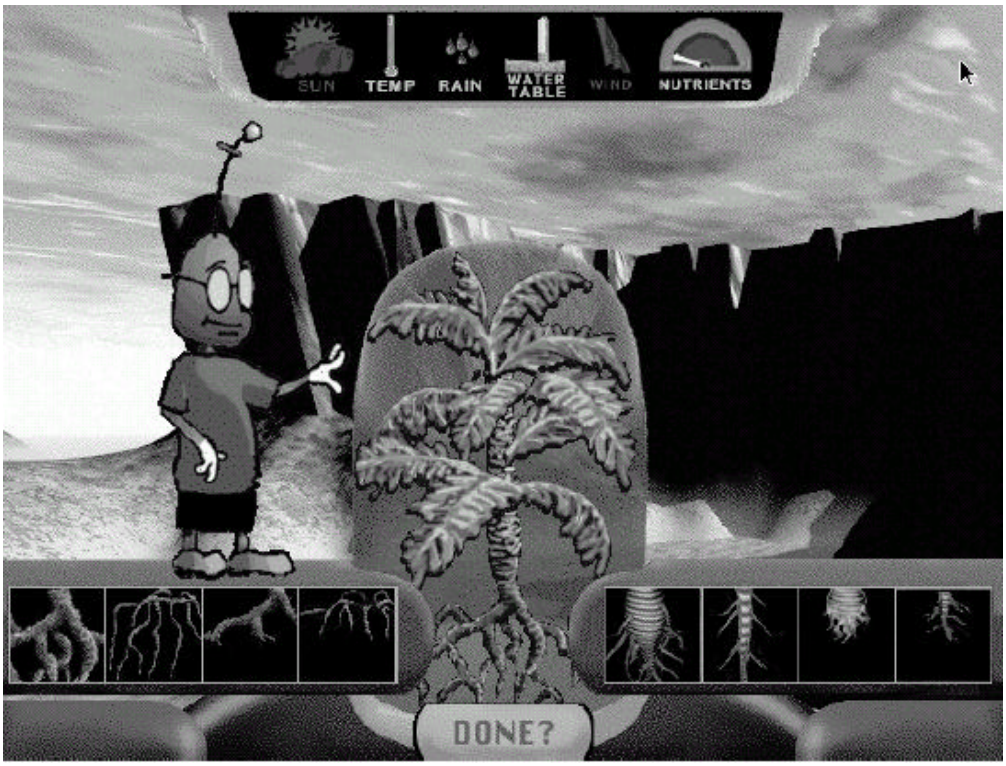

Figure 2.4 – Herman the bug and the Design-A-Plant learning environment

In 1997, James Lester led North Carolina State University's IntelliMedia Initiative, an international interdisciplinary group of Computer Scientists, Psychologists, Graphic artists, Programmers and Instructional designers to produce "Herman the bug" and the Design a plant learning environment. Design-A-Plant learning environment is a design centered microworld (Lester et al., 1997). The purpose of this multimedia program is to instruct students in botanical physiology and the environmental factors that allow a plant to survive on earth.

Lester et al. conducted a large scale empirical study to determine the affective impact of pedagogical agents on students' learning experiences. In this study they discovered what they describe as "the Persona effect:"

> *… the presence of a lifelike character in an interactive learning environment — even one that is not expressive — can have a strong positive effect on student's perception of their learning experience (Lester et al., 1997).*

In this study investigators compared five "clones" of Herman the bug to determine which would have the most impact. They used a pretest posttest design involving 100 students (50 females; 50 males) who were enrolled at a local middle school. The five behaviors states for the Herman "clones" were as follows:

1. Fully Expressive - Principle-Based, Task-Specific, and audio/animated advice
2. Principle-Based Animated/Verbal advice
3. Principle-Based Verbal advice
4. Task-Specific Verbal advice
5. Muted

Data from an 18 question likert scale, paper and pencil survey which included free formed responses, showed no significant differences between pretest scores. However post test scores were significantly higher.

So Lester and his colleagues determined that learning occurs when pedagogical agents are introduced into a learning environment. But more importantly they determined that motivation is higher when an agent is more expressive and offers varied forms of feedback.

In a follow-up study Moreno, Mayer, Spires, and Lester (Moreno et al, 2001) also looked at the Design-a-plant environment and Herman-the-bug, but this time included another audience - undergraduate college students. The result from Lester's previous work was confirmed for both audiences; and in addition Moreno's group was able to demonstrate that students learned more deeply, based upon evidence from their transfer tests. So not only is there a "persona effect" as described by Lester, but also this pedagogical agent seem to help students learn more deeply.

2.5.2 Steve (Soar Training Expert for Virtual Environments)

The USC Information Sciences Institute's Center for Advanced Research in Technology for Education (CARTE) has developed another animated pedagogical agent: Steve (Note figure 2.5).

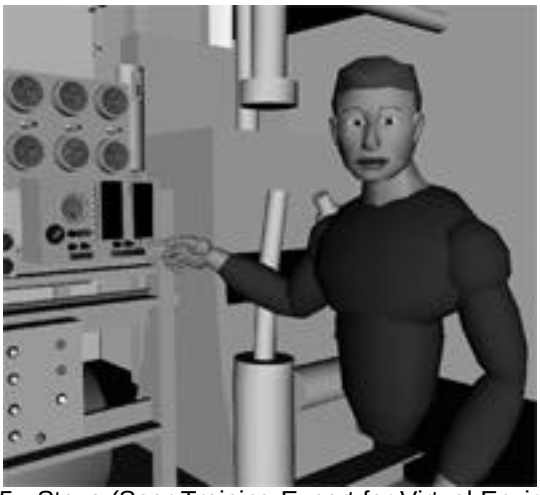

Figure 2.5 - Steve (Soar Training Expert for Virtual Environments)

Steve is a pedagogical agent that inhabits a Virtual Reality simulation. Steve's role is to train cadets in naval training tasks such as operating the engines aboard US Navy surface ships (Johnson & Rickel, 2000). A limitation of this type of agent is that it requires virtual reality hardware and a great deal of design effort. Herman-the-bug required a similar level of development with a multidisciplinary team of programmers and graphic artists to produce his behavior sequencing engine (Lester et al., 1997).

2.5.3 Multiple Intelligent Mentors Instructing Collaboratively" (MIMIC)

A group of researchers at Florida State University has taken a somewhat different approach. They are using a software product known as Microsoft® Agent. The use of this technology may make the present project possible. This group of researchers at FSU is under the direction of Dr. Amy Baylor. This project is an intelligent web-based agent environment for learning instructional design (Note figure 2.6) (Baylor, 1999a).

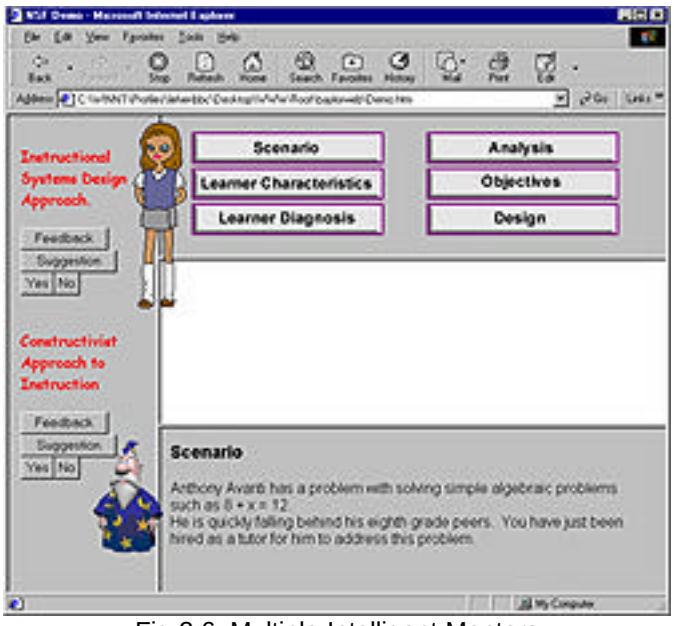

Fig 2.6. Multiple Intelligent Mentors Instructing Collaboratively" (MIMIC)

The developers of MIMIC are interested the following objectives (Baylor, 1999a):

1) to describe the implementation of metacognitive and reflective thinking in the system;
2) to describe updated views of intelligence in education based on the artificial intelligence techniques used as part of the system together with learners' experience with the expert pedagogical agents;
3) to conceptualize the strategies that the pedagogical agents "learn" through interacting with each other and with the users of the system;
4) to investigate the resolution of conflict for the user as a result of working within a system that provides diverse and sometimes contradictory instructional strategies;
5) to examine how the use of MIMIC shapes current theories of instruction through analysis of learners' interactions with the system; and,
6) to examine how the development of MIMIC shapes current theories of instruction through analysis of the methods developed in creating the system.

2.6 The Social Aspects of Agents

Well-known author and computer scientist Donald Norman believes that our main difficulty with software agents is not a technical problem, but a social one (Norman, 1994). This is because these systems have two important characteristics, "autonomy" and "the ability to interact with humans." Because of these characteristics he describes them as having "potential for social mischief." For "a smooth introduction of this technology into our society," Norman believes we need to consider how people feel about agents; and their comfort with, or acceptance of their automatic, autonomous actions (Norman, 1994).

Acceptance or rejection of agents could be seen as a social reaction of humans. And indeed a new paradigm in human-computer interaction has arisen over the pass decade to describe this phenomenon. The "Computers are Social Actors" (CAS) paradigm (Nass et al., 1994) describes the social interactions of humans and computers. In order to fully describe the social aspects of humans toward agents, this section then will discuss Norman's concerns of how people feel about agents, and also their reactions or behaviors toward agents.

2.6.1 The Social Aspects of Computing

Clifford Nass, a social psychologist from Stanford University, led a group of researchers, in a series of studies, to observe that ordinary computer-literate individuals can be induced to use social rules toward computers and thus behave as if computers were human (Nass et al 1993; Nass & Steuer, 1994; Nass et al., 1995; Nass et al., 1997). Each of these studies showed that people tend to apply social rules to computers. Nass describes this as a new paradigm in Human-Computer Interaction known as the "Computers are Social Actors" (CAS) paradigm (Nass et al., 1995). In the next few subsections the details of this CAS paradigm will be further detailed.

2.7.1.1.1 Anthropomorphism, Agency, & Ethopoeia

Anthropomorphism is a word familiar to most people. Meriam and Webster's Dictionary describes it as "an interpretation of what is not human or personal in terms of human or personal characteristics (Merriam-Webster, Inc., 2001)." Although this word is often used negatively to denote how individuals are being duped by there surroundings, it is similar to what Nass et al. (1993) describe as natural human behavior. Nass et al. (1993) noted "that a minimal set of characteristics associated with humans provides sufficient cues to encourage users to exhibit behaviors and make attributions toward computers."

In their initial study asked the question "Can adults be induced to use social rules distinguishing "self" and "other" to respond to the behaviors of technologies (Nass & Steuer, 1994)?" They used a 2x2x2 between-subjects experiment to observe participant's reactions (N=88) to computers that used voice output, during tutoring and evaluation sessions. This set of experiments used three separate manipulations:

- The participant's performance during the tutoring session was either praised or criticized.
- The evaluation computer used the same voice or a different voice as the tutoring computer.
- Evaluation of a participant's performance was made via the same or a different computer as the tutoring session.

They found that participant's distinguished between voices, but not separate computers, while applying several social rules. Interestingly enough these social rules were used repeatedly in a "distinguish 'self' from 'other'" behavior. Again these outcomes were evident even though participants' knew that they were interacting with computers. Obviously belief does not necessarily guide behavior. They termed these seemingly unnatural behaviors as "ethopoeia" meaning "the assignment of human attitudes, attentions, or motives to non-human objects (Nass et al.,1993)" The word itself comes from the Greek words *ethos*, "character" and *poeia*, "representation." Experimental participants may vehemently deny such actions, but observations prove otherwise.

2.7.1.1.2 Are Computers Gender Neutral?

In 1997, Nass, Moon and Green published a study entitled *Are Machines Gender Neutral? Gender Stereotypic Responses to Computers with Voices.* Certainly machines are gender neutral!

But, according to the research produced by Nass et al. (1997), people tend to treat computers differently, depending on their synthetic "voices." This topic proves to be quite controversial as the literature of gender and social roles is quite prolific and in many cases political in nature. To better understand this topic as it relates to their work, Nass et al. tested three stereotypic responses that humans display in human-to-human interpersonal relationships.

1. "Evaluation from males is more valid than evaluation from females (Robinson & Macarthur, 1982)."
2. "as agents of influence, men are regarded as more dominant and influential and as more effective leaders than women…(Eagly & Wood, 1982, p916)"
3. "Women know more about subjects that are typically regarded as 'feminine,' where as men know more about subjects that are typically regarded as masculine."

The 1997 Nass et al study, was a 2x2x2x2 (Subject Gender x Tutor voice: Male/Female x Evaluator Voice: Male/Female x Topic: Computers, Love and relationships) mixed design, N=40. The subjects were undergraduate students which were familiar with computers (extensive word processing experience).

The results of the above experiments confirmed their earlier predictions as a part of Nass' "Computers Are Social Actors" Paradigm. Humans as it seems do relate to computers depending on the gender of their "voices."

2.7.1.1.4 Implications of Social Computing Behavior

Unfortunately the number of participants in many of the social experiments mentioned above was small, making these results somewhat questionable. But these experiments do demonstrate the possibility of this behavior. Therefore the social implications of computing should not be under estimated for it may mean humans may unconsciously respond to computers and more specifically agents in a social manner.

These results then do provide sufficient evidence to warrant consideration during instructional design. The design implication here is that the "casting" of a voice is an important consideration (Nass et al., 1997), for the gender of the voice may affect learners in ways not intended. Because agents have a potential for "social mischief" designers should be careful when developing pedagogical agents.

2.8 Summary

In addition to the social aspects of agents designers should also be aware of the pedagogical aspects of agent design. In particular designers should concentrate not on the technology involved as demonstrated by the Clark/Kozma debate but on what's important – learning. Given this important lesson, this study then will concentrate on the instructional aspects of agent based instruction.

The instructional message delivered by an agent, as mentioned previously, is primarily delivered via the auditory channel. But as Mayer (1997) described, just one mode of instruction is less productive than two modes of instruction. This study then proposes to investigate under what conditions, and especially, for whom, agent-based instruction can be effective.

2.8 Research Questions

To address the above mentioned purpose of this study two research questions will be asked:

Is achievement (in agent-based instruction) dependent upon the use of visuals (images)?

Is achievement (in agent-based instruction) dependent on a learners listening ability (as measured by the Watson-Barker listening test)?

Chapter 3 – Methods

"All my life, I have been fascinated by the big questions that face us, and have tried to find scientific answers to them."
Stephen Hawkings

3.0 Introduction

The overall design for this dissertation will be a Developmental Design. This is because it will include the development of a web based course module. The specifics of this design element will be described in section 3.1. In addition this project will include quantitative and qualitative elements (described in sections 3.3 and 3.2 respectively).

Qualitative and quantitative measures can be used together to provide complementary perspectives and research outcomes (Patton, 1990; Ross & Morrison, 1996). Sieber (1973) suggests that the integration of these techniques can benefit the researcher during the three major phases: design, data collection, and analysis. Each method will then be strengthened by the unique qualities of the other (Sieber, 1973).

Balancing internal and external validity is a central issue in Instructional technology research (Ross & Morrison, 1996). This is because laboratory data tends to be weak in external validity and strong in internal validity. But instructional designers need to test their products under field conditions to get a true sense of their worth. It is necessary then to design experiments so they are adequately controlled but still able to yield meaningful data. By employing a mixed model design, instructional designers are able to cross-validate their research.

3.0.1 Sample

The sampling strategy used, will be that of a sample of convenience. Individual students enrolled in several sections of the course "Introduction to Educational Technology (EME 2040)" will be randomly assigned to the treatment conditions. This class is taught at the sophomore level at the University of South Florida (USF). In addition it is also taught throughout the state at a number of community colleges. In particular, there are four regional campuses of Hillsborough Community College (HCC), within close proximity of USF. In order to meet the requirements of both research questions individuals from both institutions will be sampled.

Individuals will be sampled from the population and then randomly assigned to matched pairs (based upon their scores on an adapted form of the Watson-Barker listening test – described more fully in section 3.3). It is expected that this research will be conducted during the spring semester of 2004. Enrollment for spring 2002 at USF exceeded 150 students. A matching number of students from HCC will also be sampled. This sample of roughly 300 learners, should provide a highly generalizable, varied sample for the twelve groups necessary for the proposed design.

3.1 Developmental design element

Because Instructional Designers serve an audience and human knowledge is the product, it is imperative that our research be fruitful. As Tom Reeves discussed a developmental approach to research is "a moral responsibility (Reeves, 2000)." Reeves continues by describing that applied research should hold more promise given a development approach. In his words:

> *"Researchers with development goals are focused on the dual objectives of developing creative approaches to solving human teaching, learning, and performance problems while at the same time constructing a body of design principles that can guide future development efforts. " (Reeves, 2000)*

This project then will be an applied developmental distance-learning project. It will be a long-term effort with the intent of "constructing a body of design principles." This type of research project may take longer and require more logistical support, but its goal is a noble one. An important goal of this study then is to determine what attributes are required for the production of a "good" pedagogical agent.

This developmental design will include the design, development and implementation of a web-based course. Its goal again is to determine what attributes are required for the production of a "good" pedagogical agent. The development of this web based course will provide a series of results that can be described as "lessons learned" during the development of the program. A log of these results has already been started, as production is already underway. This information can currently be found at: http://www.coedu.usf.edu/agents/

3.1.1 Microsoft® Agent Technology

Even though Microsoft refers to Clippit® as an "Office Assistant" within Microsoft® Office (Winter & Winter, 1998), it is actually an instance of Microsoft® Agent (note figure 3.1).

Figure 3.1. Microsoft® Agent 2.0 characters
"Robby the robot", "Peedy the parrot", Genie, and Merlin

Microsoft® Agent allows developers to provide agents within stand alone Windows applications and also web pages. This ActiveX component allows for a variety of animated gestures to create believable characters and text-to-speech for voice simulation.

A non human agent like “Peedy the parrot” will be used during the study to limit bias that may be due to gender, age or ethnicity of the agent. Unfortunately the freeware version of Lernout & Hauspie TruVoice Text-to-Speech (TTS) Engine which accompanies Microsoft® Agent only includes male voices.

3.1.2 The Microsoft Agent Character Editor

Just as a wide variety of Office Assistance are available in Microsoft Office, there are a wide variety of Agent Characters available for designers. The above listed characters have limited uses in instruction. Their genders, inherent personalities and gesture constrain the use of this technology. Microsoft understood these limitations and built a character editor. This program enables the developer to compile character animations for use with Microsoft® Agent. The program lets a developer define animations by importing Windows bitmap images and setting their duration. Character Animations could be built with any graphics program, but 3D animation programs such as Poser or Strata 3Dpro would produce a better product (Note Figure 7).

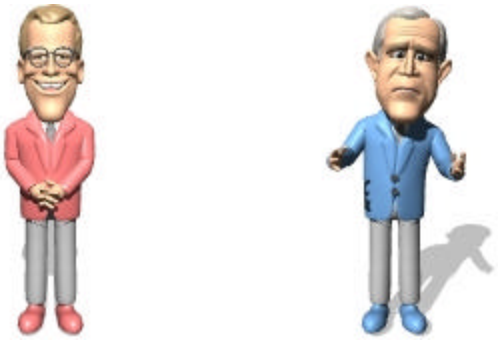

Figure 3.2. Some Example Characters built with Poser
Source http://www.animatronix.com/

Developer's also have the option to include branching, sound effects, and speaking overlays. In addition, this program lets you define a character's name and description, as well as output options that include text-to-speech capabilities, synthesized voice output, pop-up menu support, and word balloon design.

Given that the user has Lernout & Hauspie’s TruVoice Text-to-Speech (TTS) Engine installed on their computer the above script should work on any computer that is connected to the internet.

3.1.3 Scripting

Agent actions can be scripted into web pages by using languages like VBScript and JavaScript. The only information traveling from the web server to the client is the scripted code. Voice then is scripted and encoded into the web page’s source code and then translated on the client machine from text-to-speech. This low bandwidth

multimedia format was designed for the World Wide Web. The following is a sample script in which Merlin appears, greets the learner and then disappears:

```
<OBJECT ID="AgentControl" width=0 height=0
 CLASSID="CLSID:D45FD31B-5C6E-11D1-9EC1-00C04FD7081F"
 CODEBASE="#VERSION=2,0,0,0">
</OBJECT>
<OBJECT ID="TruVoice" width=0 height=0
 CLASSID="CLSID:B8F2846E-CE36-11D0-AC83-00C04FD97575"
 CODEBASE="#VERSION=6,0,0,0">
</OBJECT>
<SCRIPT language=VBScript>
Sub window_OnLoad
        AgentControl.Connected = True
        AgentControl.Characters.Load "merlin",
        "C:\WINDOWS\MsAgent\chars\merlin.acf"
        Set merlin = AgentControl.Characters("merlin")
        merlin.LanguageID = &H0409
        merlin.Get "State", "Showing, Speaking"
        merlin.Get "Animation", "Greet, GreetReturn"
        merlin.Get "State", "Hiding"
        Set merlin = AgentControl.Characters("merlin")
        merlin.Show
        merlin.Play "Greet"
        merlin.Speak "Greetings! I am Merlin, your humble servant.
                        Goodbye for now!"
        merlin.Hide
End Sub
</SCRIPT>
```

Figure 3.3 Microsoft Agent VBScript

3.2 Qualitative elements

As is often the case in developmental design qualitative data will be used to further develop the distance learning module (described in section 3.3). Two common developmental tools used by qualitative researchers are interviews and focus groups. This project will make use of these two types of qualitative data. As described earlier, Qualitative data need not be unscientific (Mayer, 2000).

3.2.1 The Interview

The design of an interview needs to be structured with a predefined list of questions (Fowler & Mangione, 1990). This is because there are numerous sources of error that can arise as the result of a mismanaged interview. The questions could be misunderstood, require information the respondents do not have, or be questions respondents are unwilling to answer (Fowler & Mangione, 1990). Therefore questions must be constructed in such a way that they are concise and easily understood by all.

In addition interviewers can be a source of error as well. This can result when an interviewer does not read questions as written or they ask probing questions that lead the respondent. It is also possible for interviewers to record answers inaccurately (Fowler & Mangione, 1990). Questions will be written so they are easy to say. They will also studied and read aloud several times before the interview. In addition, the interview will be recorded (via audiotape) for later analysis.

3.2.2 Focus Group

Focus groups are very similar to interviews and have many of the same concerns as interviews. However focus groups do differ from interviews for they have considerations all their own.

For many of the same reasons listed above, the focus group questions must be structured and non directional. It is also imperative that the interviewer sets a tone as leading the discussion. The questions for a focus group are similar to those of an interview. But because there are more respondents the discussion can easily get out of hand. For that reason it is necessary to limit the number of respondents.

Marketing research may have as many as 10 to 12 respondents. But for research of this nature it will be necessary to keep that number limited to six or seven (Krueger & Casey, 2000). Finally the focus group will be taped for later analysis.

3.2.2.1 Validation of Interview and Focus Group Questions

It is necessary to validate the questions asked during Interviews and Focus Groups (Krueger & Casey, 2000). To do so, questions will be asked, during a pilot test, with a small group of individuals (three to four) (Krueger & Casey, 2000). This is to insure that all questions are understood. In addition, at the conclusion of the pilot and actual experimental focus group participants will verify summary comments (Krueger & Casey, 2000).

3.2.3 Qualitative Data Analysis

The data from both the focus group and interviews will be in the form of recorded audio. Following the focus group or interview, audiotapes will be replayed, and a transcript developed at the lexical level as described by Lemke (1998); i.e., "by preserving the sequence of whole, meaningful words and meaningful non-lexical vocalizations." This general process is called discourse analysis.

A more specific form of discourse analysis described as enumerative analysis by Le Compte and Preissle (1993) is when transcripts are coded for construct categories. These construct categories then can be analyzed for frequencies.

Triangulation of the quantitative and qualitative data from the survey, interviews, and focus group, may prove fruitful. But it has also been shown that triangulation can produce inconsistencies and contradictions (Mathison, 1988). When this happens it is still possible to validate your findings by reconciling them within some explanatory framework (Gall, Borg, & Gall, 1996).

3.3 Quantitative elements

In addition to the above-mentioned qualitative elements the design of this project has several quantitative elements. Three types of instruments will be used to gauge and understand achievement: a pretest will be conducted to control for prior knowledge, a modified version of the Watson-Barker listening test (Watson & Barker, 1988), and an achievement posttest. This achievement test will be developed and administered to understand how students perform after having been exposed to the experimental treatments (discussed in the next section). The content validity of both the pretest and

post-test will be addressed by having an expert in Educational Technology judge completeness.

3.3.2 Quantitative Methods

The research in this study will be conducted in several phases:

Phase I - Pilot test

A pilot test of the above mentioned assessment tools and distance learning module will be conducted during fall semester 2003. To accomplish this task, a representative sample of students from the fall 2003 semester section of EME2040 from both USF and HCC will take part in this pilot.

Students will take the pretest, the achievement test, and the modified Watson-Barker listening test. There will be several goals of this pilot test. One will be to estimate the duration the agent-based instruction. Also it will be necessary to discover "good" and "bad" items on the achievement test. Finally a "pilot" interview and focus group will be conducted as well to test their respective questions.

Phase 2 - Prior knowledge pretest.

The above mentioned prior knowledge pretest will be administer to the study sample during spring 2004. The purpose of this test is of course to gain an understanding of the student's level of prior knowledge.

Phase 3 – The Modified Watson-Barker listening test

Two well known listening experts Watson and Barker, suggest that listening is not a skill but a complex process (Watson & Barker, 1988). To investigate and better understand listening they developed the Watson-Barker listening test. Since it was developed a number of researchers have used this test as a listening comprehension measurement tool (Watson & Barker, 1988). A modification will be made in that an agent (as opposed to a person) will read aloud all verbal instruction. This will be administered to control for listening ability and determine the matched pairs for the experimental conditions during phase 4 (experiments 1 & 2)

Phase 4 – Experimental conditions

Experiment 1 – Verbal Instruction & Visual Representations

As mention previously Mayer (1997) suggests that the addition of visuals may improve retention and comprehension during verbal instruction. Being that agent based instruction is primarily verbal a test of his theory will be made. This (Experiment 1) will include verbal instruction and the addition of visual information.

Listening Ability	Control	Experimental
High		
Medium		
Low		

Experiment 2 - Verbal Instruction only

Next Experiment 2 will be identical in every way except it will not have the visuals mentioned during Experiment 1.

Listening Ability	Control	Experimental
High		
Medium		
Low		

3.2.3 Qualitative Data Analysis

Data from the above will be analyzed using an analysis of variance ANCOVA. An ANCOVA can either be seen as an extension of an ANOVA or as an extension of linear regression. This statistical procedure is used to control for initial differences between groups, before comparisons of within groups variance and between groups variance, is made (Gall et al., 1996). An ANCOVA is useful because the sample in this study is composed of two groups that may differ on relevant variables (i.e. Listening Ability) (Gall et al., 1996).

3.4 Limitations of the study

There are two types of limitations for this study.

1) The first of these is the nature of the sample used. Students will enroll in this class on a voluntary basis, therefore participants will be self-selected. This will cause several important biases. Most important of these is that the demographics of the class will be somewhat suspect. Gender, ethnicity, socioeconomic status and many other demographic variables will not represent undergraduate students as a whole. Important demographic variables will be monitored but can not be controlled.
    a. Either the control or experimental group may become demoralized as a result of receiving differential treatment.
    b. Attrition could become a potential problem if students drop out of the course.
    c. Individual students' computer aptitude or "savvyness" could be a potential problem. Because of their lack of computer skills participants may have technical difficulties that may influence there achievement and/or attitude toward the course.
    d. Because demographics will not be control the agent's gender, age or ethnicity could influence outcomes and be a potential bias.

2) In addition internal problems could arise as well. For instance assessments may impart some bias.
    a. Triangulation could potentially produce inconsistencies or contradictions.
    b. Researcher bias could potentially influence the collection of data. Every effort will be made to prevent this bias.

3.5 Delimitations

The root of this word delimitation is "delimit" which quite literally means "define the limits." The delimitations of this dissertation then describe populations to which generalizations may be made (Locke et al., 2000). The data produced by this study may only be applicable to instructional media used with undergraduate students (freshman, sophomore, junior, and seniors) in a distance learning environment. Qualitative findings should not be generalized as they will only describe the population sampled under the treatment conditions at the time of treatment.

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