EFFECTS OF AN ANIMATED AGENT WITH INSTRUCTIONAL STRATEGIES IN FACILITATING STUDENT ACHIEVEMENT OF DIFFERENT EDUCATIONAL OBJECTIVES IN MULTIMEDIA LEARNING

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by
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ABSTRACT

The purpose of this study was to examine the effects of an animated agent that provides instructional scaffolding strategies via a story mnemonic or cuing question with feedback versus instructional scaffolding strategies alone on student achievement of different educational objectives in multimedia learning. Specifically, the study investigated the effects of two animated agent conditions (with an animated agent, without an animated agent) with two instructional scaffolding strategies (story mnemonic and cuing questions with feedback) on knowledge and comprehension when controlling prior knowledge and field dependence/independence (field independence/dependence) in multimedia learning.

MANCOVA results indicated no significant differences between the animated agent conditions and the instructional scaffolding strategies or the interactions between the two factors on items associated with manipulated screens when controlling for prior knowledge on knowledge. Similar results were found for the comprehension. No significant main effects were found for instructional scaffolding strategies or the interaction between the two animated agent conditions and instructional scaffolding strategies.

In addition, a significant interaction was found between the animated agent conditions and field dependence/independence on comprehension. That is, when the animated agent was absent, field dependent learners scored significantly higher than field independent learners.
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Chapter 1

Introduction

Multimedia learning is defined as the way an individual “builds mental representations from words and pictures, such as illustrations, and animations” (Mayer, 2005, p. 15), such as dynamic graphics on the computer screen. For example, the features of multimedia environments can display a complex science system step by step, with text and dynamic graphs. In turn, this step by step approach supports learners to understand the content more effectively.

In order to understand how multimedia learning affects thinking, Mayer (2005) proposed three views: response strengthening, information acquisition, and knowledge construction. Response strengthening is aimed at helping the learner connect stimulus and response. This view does not accurately portray the multimedia view in this study because the view simplifies the learning process. In the second view, information acquisition, learners are perceived as passive receivers who store information in their memory without integrating it. In this view, the multimedia environment is perceived as a pure delivery system for presenting the information. Last, knowledge construction in multimedia learning is a sense-making process in which learners build their understandings by integrating pictures and words with what they know. Specifically, the features of multimedia guide the learners thinking. When the learner is supported by on screen text and diagrams, it is expected that they construct a coherent understanding of the content.
Because of interactive elements of multimedia, instruction can be scaffolded, and in turn, aid cognition. In particular, learners play an active role by interacting with instructional stimuli which aids in retaining information for later recall. Research studies suggest that instructional guidance be designed to provide interactive supports, such as inserted questions with practice (Chee, 1994).

In recent years, researchers have perceived the potential for embedding animated agents in multimedia environments. The animated agent is placed next to the instructional strategy so that it appears that it is providing the scaffold to the learner (Chee, 1994; Moreno, Mayer, Spires, & Lester, 2001). Extensive research indicates that using animated agents with interactive multimedia scaffolds can lead to learning improvements (Moreno, 2005; Spires & Lester, 2001). An animated agent in multimedia learning not only provides learning support but can also be engaging and motivating (Dehn & Van Mulken, 2000). Lester and Stone (1997) hypothesized that this may be due to the believability of the animated agent. They found that the believability of the animated agent which has visual impact and complex behavior motivates students most. With the presence of the animated agent, it is easier to capture students’ attention so they see and engage in knowledge construction. In addition, Elliot, Lester and Rickel (1997) suggested that due to the high visual impact of the animated agent, students’ concentration and involvement would be longer. Consistent with previous studies, Moreno, Mayer, Spires, and Lester (2001) extended empirical support for the presence of the animated agent with their findings that its presence promoted academic motivation and enhanced constructivist learning.
In the research reported here, the objective was to contribute to the development of guidelines for the effective use of animated agents that provides pedagogical support. Recent studies found that connecting scaffolding with animated agents can advance learning and facilitate learners’ ability to build coherent understanding (Baylor, 2002; Chee, 1994).

In addition, verbal mnemonics, as elaboration, have been considered as an effective pedagogical support for enhancing learning (Bellezza, 1981). Empirical evidence shows that using verbal mnemonics can lead to significant performance in a numbers of domains, specifically in learning abstract and complex scientific phenomena (Levin et al, 1982; Levin, 1983). Therefore, connecting an animated agent with verbal mnemonics should support learner’s cognitive processes and promote learning in a multimedia environment.

Lajoie and Nakamura (2005) urged researchers to examine the way in which multimedia design can support learning rather than comparing the effectiveness of different delivery modes. The promise of multimedia learning is that students will enjoy better understanding as a result of receiving verbal and visual guidance (Mayer, 2003). To further explore the potential of multimedia learning, research studies have been conducted to examine the assumptions of a multimedia environment for enhancing learning (Levin, 1993; Mandler, 1979). However, it is important to examine the combination of an animated agent design with instructional strategies in order to promote learning.
Statement of the Problem

A number of researchers have examined how multimedia enhances human learning. Specifically, research has focused on the relationship between the design features of multimedia and human learning (Mayer, 2005). Although advanced technology has the potential to increase understanding of human cognition, Norman (1993) found that existing research has focused on the machine-centered view rather than the learner-centered view. The major challenge of multimedia design in support of the cognitive process remains unresolved (Lajoie & Nakamura, 2005; Mayer, 2005).

Learning is an active and constructive process in which learners interact with information in the environment (Shuell, 1988). Cognitive studies have emphasized active learning and seek to understand the interaction between internal cognitive processes and instructional scaffolding strategies that are mediated by the features of the media. Although there has been some success in integrating cognitive perspectives into instructional scaffolding strategies, existing research has not been sufficient in providing an understanding of the interaction between an animated agent and the cognitive outcomes in the multimedia learning.

In addition, within the context of information processing theory, cognitive processes in multimedia learning have faced another challenge for instructional designers. Based on previous research findings, an examination of the effectiveness of multimedia is no longer a question (Mayer, 2003). Instead, research should be focused on multimedia designs through cognitive perspectives (Hannafin & Rieber, 1989). For example, Schramm (1977) claimed that learning is affected more by the content and instructional
strategy than by the type of medium. Later, Clark (1994) pointed out that no learning gains have been found among media studies; this may be due to the different features similarly shared by media and cognitive functions. Specifically, with careful consideration of cognitive processes and design of instructional scaffolding strategies provided by an animated agent in multimedia learning, significant learning improvement should be found.

Proposed Solution

Ideally, an animated agent is designed as a visual computer character and has the potential for aiding learning (Sampson, Karagiannidis & Kinshuk, 2002). The animated agent provides the opportunity for educators to rethink instructional strategies in the multimedia environment. Researchers have started exploring the use of the animated agent from a cognitive approach (Lowe, 2004; Scaife & Rogers, 1996). Lester and his colleagues (1997) found that the animated agent promoted a more coherent understanding of the content when it provided advice for learners than when the animated agent was not present or did not provide feedback. The guidance feature of the animated agent can support individual learning and have a social character that cannot be provided in traditional computer-based environment (Baylor & Kim, 2006). With these assumptions and in exploring interests, Chee (1994) confirmed that learners performed better with the animated agent because it enabled them to take on an active role than a passive role. However, not much of the literature in cognitive psychology has examined the relationship between the animated agent and scaffolding (Rieber, 1990). Specifically, no known research has fully articulated instructional strategies provided by the animated agent in order to facilitate learners’ understanding. Identifying whether or not animated
agent with scaffolding can facilitate learning will advance existing instructional design
theories and thereby support designers.

Field dependence/independence, as a description of how learners perceive
information, has been researched for years and impacts a learner’s innate approach to
learning (Chen & Macredia, 2002; Clark & Choi, 2005). Witkin, Moore, Goodenough and
Cox (1977) developed the concept of field dependence/independence to explain how
learners mentally organize information. Field dependence/independence can explain how
learners use salient cues to and restructure information (Weller, Repman & Rooze, 1994).

To illustrate, Witkin and his colleagues (1977) described field independent learners
as those who rely on internal references to comprehend information and are able to
extract the relevant cues from the learning environment. On the other hand, field
dependent learners rely on external references and are less discriminative. In a review of
field dependence/independence studies, empirical evidence showed that field dependent
and field independent learners approach instructional guidance and structural information
differently (Reed & Oughton, 1997). Further, Ayersman and Minden (1995) suggested
that multimedia has “the capacity to accommodate individual learning style differences
because of its flexibility and potentially high level of learner control” (p. 371). With its
flexibility, multimedia presents instruction via more than one mode and supports learners
in understanding concepts through various design features. By being provided direct
prompts as cues for questions and seeing the animated agent as a social character, field
dependent learners should perform better than field independent learners. Alternatively,
when using the story mnemonic for learning, field independent learners organize the
information and gain a comprehensive understanding of the content. The design is based
on information processing and the levels of processing framework (Atkinson & Shiffrin, 1968; Craik & Lockhart, 1972) which emphasize memory structure to organize and reinforce information. Learners can use various instructional strategies or cues to approach the information (Ayersman & Minden, 1995). It is therefore critical to map the cognitive attributes of field dependence/independence with the design of multimedia learning to maximize learning outcomes. That is, supported by two instructional scaffolding strategies, field dependent/independent learners should comprehend the content in a more meaningful way.

Purpose of the Study

The purpose of this study was to examine the effects of an animated agent that provides instructional scaffolding strategies via story mnemonic or cuing questions with feedback versus instructional scaffolding strategies alone to ascertain student achievement of different educational objectives in multimedia learning. Specifically, the study investigated the effects of two animated agent conditions (with an animated agent, without an animated agent) with two instructional scaffolding strategies (story mnemonic and cuing questions with feedback) on knowledge and comprehension when controlling prior knowledge and field dependence/independence (field independence/dependence) in multimedia learning.

This research also responds to the need for empirical evidence of the use of animated agents to enrich current understanding of human cognitive processes and the role of the animated agent as it provides pedagogical supports in the design of multimedia learning.
Research Questions

The study was designed to examine the effects of an animated agent that provides instructional scaffolding strategies via story mnemonic or cuing question with feedback on student achievement in multimedia learning. Based on the theoretical framework, five research questions were investigated:

1. Do field dependence/independence and prior knowledge predict knowledge and comprehension?

2. Is there a main effect of instructional scaffolding strategies on knowledge and comprehension when controlling prior knowledge and field dependence/independence?

3. Is there a main effect on animated agent conditions on knowledge and comprehension when controlling prior knowledge and field dependence/independence?

4. Is there a significant interaction between animated agent conditions and instructional scaffolding strategies on knowledge and comprehension when controlling prior knowledge and field dependence/independence?

5. Is there a significant interaction between field dependence/independence on animated agent conditions and instructional scaffolding strategies on knowledge and comprehension?

Research Hypotheses

Null hypotheses were generated as follows:

Ho1: Prior knowledge will not significantly predict knowledge or comprehension.
Ho 2: Field dependence/independence will not significantly predict knowledge or comprehension.

Ho3: There will be no statistically significant difference between instructional scaffolding strategies on knowledge or comprehension

Ho4: There will be no statistically significant difference between animated agent conditions on knowledge or comprehension.

Ho5: There will be no statistically significant interaction between animated agent conditions and instructional scaffolding strategies on knowledge or comprehension.

Ho6: There will be no statistically significant interaction between field dependence/independence on animated agent conditions and instructional scaffolding strategies on knowledge or comprehension.

It was hypothesized that students supported by the animated agent with either the story mnemonic or cuing question with feedback would achieve higher scores on knowledge and comprehension than those receiving instructional scaffolding strategies alone. In addition, with respect to different field dependence/independence, field dependent learners are predicted to perform better when the animated agent provides cuing question with feedback than field independent learners due to its making cues salient and the social character of the animated agent (Witkin, Moore, Goodenough & Cox, 1977). In addition, it was assumed that field independent learners would perform better than field dependent learners when using story mnemonic because field independent learners tend to be systematic and detailed when they organize content (Goodenough, 1976).
**Justification for Studying Field Dependence/Independence**

The heart content is designed in a hierarchical structure from facts about the heart and its function. Learners need to break down and organize the structure in order to comprehend the materials. Theoretically, field dependent/independent learners will approach the instruction differently in terms of how they perceive the instructional materials. That is, field dependent learners may need salient cues to help them understand and elaborate complex knowledge. Field independent learners tend to focus on the details of the instruction.

**Justification for Studying Prior Knowledge**

Research studies have indicated that prior knowledge affects learners’ ability to construct their representations through assimilation and interpretation (Chiang & Dunkel, 1992; Matthews, 1982). Assimilation is aimed at integrating new information into the existing schema. Armbruster (1986) stated when a learner actives their prior knowledge when interpreting new information, the level of comprehension of the new information is increased. Therefore, it is important to account for the effect of prior knowledge when determining treatment effects.
Definition of Terms

Animated Agent

The animated agent is the computer character that can be considered by learners as an assistant with an educational purpose (Baylor, 2002). Specifically, the animated agent functions as follows (see Figure 1.1): It

- Provides instructional explanations and feedback,
- Encourages learners to have positive attitudes toward the learning task by providing either “correct” or “incorrect” feedback,
- Can be placed at the bottom left side of the screen because eye movement flows from left to right, top to bottom. In this position, the animated agent is seen after the on-screen text and diagram.

Features of the animated agent include:

- Nonverbal features,
- Facial expressions, and
- Gestures that attract students’ attention.

Figure 1.1. Example of an animated agent
**Scaffolding**

Scaffolding is the external support that “enables a child or novice to solve a problem, carry out the task, or achieve a goal which would be beyond unassisted efforts” (Wood, Bruner & Ross, 1976, p. 90). In order to make scaffolding successful, three major features must be identified.

Features of scaffolding:

- Requires learners’ involvement in meaningful and interactive activities.
- Provides Instructional explanations for learners to comprehend the instruction more effectively.
- Provides learning supports are provided as appropriate to the difficulty of a task.

**Story Mnemonic Strategy**

Organizational mnemonics is an encoding operation that helps learners organize and interrelate new information in their memory. In addition, it acts as a learning strategy that enhances learning by helping learners to associate important concepts with existing knowledge in order to memorize factual knowledge (Bellezza, 1981). Story mnemonic is one of the organizational mnemonics in which learners can “incorporate each successive word into a story that she or he creates as the items are presented” (Bellezza, 1981, p. 255).
**Cuing Question with Feedback**

Cuing question is a question with an embedded salient cue for learners that enable them to practice their current understanding and prepare for later recall. Feedback signals learners about whether their responses were correct or not.

**Field Dependence/Independence**

Field dependence/independence is based on how learners process and integrate incoming stimuli. To elaborate, field dependent learners are individuals who perceive the field globally and are more socially-oriented (Goodenough, 1976). In contrast, field independent learners are individuals who perceive embedded contexts and are more analytic in processing stimuli and tend to be intrinsically motivated (Witkin, Moore, Goodenough & Cox, 1977).

**Knowledge**

It is the understandings of facts, terms, and definitions of the heart (Dwyer, 1972).

**Comprehension**

It is the coherent understandings of heart, its function and the internal process during the systolic phase (Dwyer, 1972).

**Prior Knowledge**

Prior knowledge consists of the knowledge from academic and personal experiences (Kujawa & Huske, 1995).
Chapter 2

Literature Review

The purpose of this study was to examine the effects of an animated agent that provides instructional scaffolding strategies via a story mnemonic or cuing questions with feedback versus instructional scaffolding strategies alone on student achievement of different educational objectives in multimedia learning. Specifically, the study investigated the effects of two animated agent conditions (with an animated agent, without an animated agent) with two instructional scaffolding strategies (story mnemonic and cuing questions with feedback) on knowledge and comprehension when controlling prior knowledge and field dependence/independence in multimedia learning.

The purpose of this chapter is to provide a critical review of existing theories that are significant to the study and justify the need to further investigate the effects of using the animated agent and these instructional scaffolding strategies. Figure 2.1 organizes three components around which this study was built: information processing model, the animated agent and scaffolding (see Figure 2.1).

The diamond shapes represents parts of the information processing model. The arrows from the rounded rectangle, which represents the animated agent, show how it impacts information processing through scaffolding. Scaffolding, showed as purple rectangles, function as pedagogical supports. The arrows from scaffolding show how it functions as pedagogical support to reduce cognitive load in working memory and by activating different cognitive process in long term memory affect comprehension.
By considering cognitive perspectives, an animated agent can be designed in different ways to scaffold learning. Studying these effects are the main focus of the research.

**Information Processing Theory**

Atkinson and Shiffrin (1968) provided a systematic view of information processing. According to the information processing model, the memory system has three storage structures: sensory register, short-term memory and long-term memory. The
sensory register holds information for a short period of time which fades rapidly because sensory receptors continue receiving information (see Figure 2.1).

**Short-Term Memory**

The process for transferring information from the sensory register to short-term memory is controlled by attention. According to Anderson (1970), attention involves encoding of the stimulus and is determined which information is transferred into short term or working memory (Kahneman, 1973). Specifically, the process of extracting information from instruction depends on the importance and salience of the stimuli (Kumar, 1971).

Once the information is in short-term memory, it is processed. One major cognitive process in short-term memory is rehearsal (Atkinson & Shiffrin, 1968). It strengthens stimulus-response links and transfers information from short term memory to long-term memory. According to Atkinson and Shiffrin (1968), the effectiveness of rehearsal depends on linking learning strategies with instructional materials and learners’ prior knowledge. Existing studies suggested that important concepts of instruction need to be salient to enhance perception and can be brought about by using prompting to direct student attention (Dember, 1960). In particular, the process can be enhanced through elaborative rehearsal, which involves adding to the meaning information for further semantic processing (Hunt & Ellis, 2004).

Another cognitive process is coding, which involves perception, comprehension and organization for connecting existing information into remembered information. Several encoding strategies can be employed to enhance encoding, such as elaboration and
mnemonic. Elaboration is one of the strategies that can transform the abstract concept into meaningful schema. Klatzky (1980) suggested that when new information is meaningfully related to prior knowledge, the information is more likely to be remembered. Mnemonic is the strategy that aid memory through elaboration on to be remembered information (Belleza, 1981).

It is important to note that both rehearsal and the encoding process depend on existing knowledge in long-term memory (Kumar, 1971). When incoming stimuli are connected to existing knowledge, encoding will be strengthened.

*Working Memory*

Baddeley and Hitch (1974) claimed a different view of the unitary concept of short-term memory and proposed a working memory model. The working memory model has two components in the cognitive process: phonological loop, visual-spatial sketchpad (see Figure 2.1). The phonological loop has the function of short-term storage and processes verbal stimuli to enable deeper coding (Baddeley, 1986). Alternatively, the visual-spatial sketchpad is limited in its capacity and temporarily stores detailed visual information, such as location of objects (Baddeley, 1986). It is important to note that working memory provides a new view of how verbal and visual information can be processed in two subsystems.

*Long-Term Memory*

The structure of long-term memory differs from that of short-term memory in terms of type of coding and capacity. When the short-term memory transfers information to the
long-term memory through the executive control, information is permanent and can be stored visually and verbally. It is assumed that long-term memory primarily stores semantic information because it encodes more specific information and results in better retention (Hunt & Ellis, 2004).

Therefore, in seeking an effective strategy to facilitate transferring information from short term memory to long term memory, this study selected a rehearsal strategy and an elaborative strategy to scaffolding instruction. Rehearsal promotes retention in short term memory while elaboration promotes encoding in long term memory.

Levels of Processing

Researchers have suggested that perception involves sensory and semantic analysis of stimuli that explains a different view of how the human memory functions (Adams, 1967; Anderson & Reder, 1979). Craik and Lockhart (1972) proposed levels of processing framework that emphasizes analysis of physical or sensory features and encoding information semantically. First, the information is transformed through recognition of physical features and then extraction of meaning. The goal for the learners is to develop strong and long lasting traces to the information stored in the long term memory. Craik and Lockhart (1972) stated that “trace persistence is a function of depth of analysis, with deeper levels of analysis associated with more elaborate, longer lasting, and stronger trace” (p. 675). The major notion is that learners process the information through perception, attention, elaboration, and adding meaning. The perceptual level at which information is perceived affects how information is encoded and stored and later retrieved.
Second, retention in long term memory is strongly related to processing information meaningfully. Semantic processing is meaningful processing and is affected by the specific context in which learning was experienced and is retained in distinctive memory more than phonemic processing. Semantic information was better recalled with cues than phonemic encodings because semantic information is associated with more meaning (Craik & Lockhart, 1972). With a richer and deeper process, such as pictures with illustrations, the information should be more distinctive.

*Distinctiveness and Elaborative Encoding*

To ensure that memory is effectively remembered, elaboration and distinctiveness are critical (Craik & Lockhart, 1972). First, distinctiveness is considered as “…how well the information encoded specifies the event being reconstructed” (Hunt & Ellis, 2004, p. 142). Extensive research has asserted that semantic processing is more distinct and will be better recalled because the distinct details of the context are encoded with the idea (Bower, 1967; Bransford & Johnson, 1972; Rock, 1975). Second, deep processing depends on elaborative encoding. Tulving and Madigan (1970) defined elaborative encoding as the process for storing additional information with to-be-remembered information. Anderson and Reder (1979) stated that individual experience counts most because the information is assimilated into their own existing schema.

By providing an environment in which elaboration and encoding are encouraged at these different levels of processing, it is expected that recall will be enhanced.
Scaffolding

The concept of scaffolding evolved from Vygotsky’s (1978) zone of proximal development. Dabbagh (2003) defined scaffolding as the structure provided in a learning environment. Specifically, pedagogical support is perceived to be important because it allows learners to perform beyond their current cognitive development level (Weller et al., 1995). Stone (1998) suggested that cognitive supports are temporary in order to aid reasoning and organization (Pea, 2004). The purpose of scaffolding is to provide supportive advice, direct attention, highlight information, and suggest the structure for content for help the learner reach cognitive maturation (Bruner, 1973; Gallimore & Tharp, 1977). Roehler and Cantlon (1997) suggested that explicit explanations scaffolds strengthen and verify learners’ current understanding during the learning process.

Hill and Hannafin (2001) described four types of scaffoldings in an online environment that enhance critical thinking. They include conceptual, metacognitive, procedural and strategic scaffolding. In this study, the research is focused on strategic scaffolding only. Examples of strategic scaffolding strategies include keywords and embedding an expert like an animated agent (Chee, 1994; Moreno, Mayer, Spires, & Lester, 2001). To elaborate, the role of the animated agent in multimedia learning is as an expert tutor who provides practice and feedback to help learners check their progress. Baylor and Kim (2006) proposed using the animated agent to scaffold instruction. When doing this, designers should consider two issues: 1) the animated agent should provide instructional supports; and 2) use the agent function when it is most needed by the learners.
Thus, in this study, an animated agent was designed to provide strategic instructional scaffolding strategies (story mnemonic and cuing question with feedback).

**Elaboration**

Elaboration has been researched with associative learning, including vocabulary learning and learning science facts (Levin, 1981; Pressley, 1982). It is defined as the process of creating, associating, and integrating new information within existing schema (Sahari, 1997). Specifically, complex learning is influenced by the elaboration process (Rohwer, 1971). Levin (1981) confirmed this assumption and showed that students who used elaboration could generate significantly more associations than other groups. Explicitly prompting students to elaborate may produce significant connection with existing concepts. Burner (1973) suggested that, compared to other strategies, elaboration adds information to new knowledge, which opens alternative pathways to that knowledge. Indeed, the rich cognitive structure created by elaboration has been found to be effective in terms of retention and comprehension for children and adult learners (Pressley, 1982).

Elaboration facilitates a learners’ ability to address important concepts, adding meaning and creating meaningfully organized encodings (Gagne & Dick, 1983). Weinstein and Mayer (1986) stated that using elaboration as a learning strategy can affect the encoding process significantly and support learners’ efforts to integrate information. Sahari (1997) conducted a meta-analytic review and provided several guidelines for applying elaboration in instruction. First, elaboration provides a cognitive structure that enhances learners’ transformation of new information into more concrete and meaningful knowledge and then applying it to their personal experience. In addition, prior knowledge
is a factor that influences the effectiveness of elaboration. That is, learners tend to have richer knowledge bases and better ability to establish coherent internal representation as grade level increases (Myers, Shinjo & Duffy, 1987). Alternatively, Jonassen (1988) approached elaboration from an information processing perspective. He proposed four different information processing strategies to promote deeper processing: recall, integration, organizational and elaboration. Specifically, he suggested that sentence elaboration, generation of mental images and generation of physical diagrams would be effective elaboration strategies.

In order to understand the function of elaboration, this study sought to focus on the effects of elaboration and create an association between new information and learners’ prior knowledge to promote deeper memory and better understanding.

*Mnemonics as Elaboration Encoding*

Mnemonics, as a keyword method, is based on elaboration encoding. Levin (1981) defined mnemonics as a strategy that involves transforming the material to be remembered into memory. In particular, mnemonics aid memory through elaborations on to be remembered information (Belleza, 1981). Most importantly, the critical concept in mnemonics is to associate information with prior knowledge with cues. Cuing helps learners retain information and retrieve it later.

The first mnemonics study was from Atkinson’s (1975) keyword method study. His study examined use of the keyword method for facilitating learning and recall. Later, Kirkpatrick (1894) posited that students performed better with the aid of a mnemonic in an immediate test. In particular, students even performed better in a delayed test. With
this promising evidence, several subsequent studies showed that learners using various types of mnemonics could improve their performance. These included the loci method, peg-word mnemonics (Bugelski, 1968; Wood & Ross, 1976), link mnemonics, and story mnemonics (Bower & Clark, 1969). The long-term effects shown in these studies persuaded educators to apply mnemonics as learning strategy in educational settings (Levin, 1983).

Levin (1987) identified three components of effective associative mnemonic techniques: recoding, relating and retrieving. Recoding involves transforming an unfamiliar stimulus into a familiar word. Relating involves the relationship between the familiar word and information with the existing knowledge. With these components encoded successfully, learners construct additional pathways to the information and have greater possibilities for information retrieval (Levin et al., 1982).

Further, Levin (1987) pointed out that when an association is established between a keyword and its meaning, a new retrieval pathway is created. Bellezza (1981) suggested that this method can be referred to as “a cognitive cuing structure” that is activated when the relevant information is presented. The keyword strategy has been confirmed to be effective when applied in learning science and has great potential in domains with a spatial component (Levin, 1985; Pressley et al., 1982). Thus, the study addressed the critical components of mnemonics. In creating mnemonic as a cognitive cue, learners can generate associations among important concepts by using mnemonic strategy.
Mnemonics in Educational Applications

Various mnemonics have been studied in educational settings, specifically in learning a second language (Bower, 1967; Levin et al., 1982). Atkinson (1975) examined the effectiveness of the keyword method in learning a second language and concluded that learners can easily access and recall the information with sufficient practice by making associations between imagery and acoustic links. In this case mnemonics help learners transform the information in meaningful schema.

Story Mnemonics

Belleza (1981) proposed two types of mnemonics: organizational and encoding. Organizational mnemonics functions to “organize and interrelate new information in memory” for later recall (Belleza, 1981, p. 255). Examples of organizational mnemonics include: method of loci, pegword mnemonics, story mnemonics, and link mnemonics. Encoding mnemonics, on the other hand, focuses on transforming the word with meaningful value or into a visual image (Bellezza, 1981). Both organizational and encoding mnemonics act as mental cues. However, encoding mnemonics is less effective with mental cues than organizational mnemonics.

The purpose of the organizational mnemonic is to associate the relevant information with existing memory. In particular, story mnemonics stresses the use of verbal representations and helps individuals make associations among stimuli. The process of story mnemonics involves learners using key words in a meaningful story. Because story mnemonics uses elaborative encoding, in turn, it helps learners process factual knowledge. Morrison and Levin (1987) suggested that the effective use of this
mnemonic strategy may be influenced by individual information processing skills. Considering that individuals encounter different experiences, it is not surprising that the effect of story mnemonics would vary by individual.

Thus, with structured content about the human heart, the use of story mnemonics should help learners make associations and connect new information to existing information in order to form a better understanding of the content.

Rehearsal

Rehearsal has been found to be an effective method of enhancing the transfer of information from short-term memory into long-term memory. The rehearsal process provides the opportunity for “adding the representation of the item in long-term memory” (Klatzky, 1980, p. 11). Craik and Lockhart (1972) suggested two types of rehearsal. First, maintenance rehearsal maintains the information in the short-term memory and does not have a significant effect on the long-term memory. Second, elaborative rehearsal enhances the storage in long-term memory by adding meaningful processing and associations with relevant knowledge. From levels of processing perspective, elaborative rehearsal can improve remembering significantly due to deeper encoding, especially if elaboration is semantic rather than phonemic. This assumption was confirmed by Craik and Watkins (1973). Although studies suggest that elaborative rehearsal is more effective than maintenance rehearsal, maintenance rehearsal can form greater associations between the information and the context (Mandler, 1979).

In addition, providing a stimulus for activating prior knowledge is also important because the degree of stability and clarity of prior knowledge can affect discriminability
during the encoding process (Ausubel, 1968; Kumar, 1971). Levin (1983) proposed four strategies for efficient acquisition of learning: rehearsal, semantic, transensory and mnemonics. Specifically, the emphasis on rehearsal is considered to involve engagement in cognitive strategies, such as visual imagery and practice (Rundus & Atkinson, 1970; Craik & Jacoby, 1979). Practicing via questions serves three major functions in computer-based instruction: (a) establish and maintain attention; (b) facilitate encoding; and (c) provide elaborative rehearsal (Wager & Wager, 1985). Specifically, the degree of retention is increased when questions are presented after reading the instructional material because questions function as rehearsal (Kumar, 1971).

Therefore, this study sought to use a cuing question as a rehearsal strategy to enhance encoding. By providing a rehearsal opportunity, it was assumed that learners may encode the information more efficiently in long-term memory.

**Cuing Question with Feedback**

Cuing is defined as a strategy that emphasizes or points out particular information in the content (Mautone & Mayer, 2001). When applied to the multimedia environment, Mautone and Mayer (2001) suggested that the function of cuing should guide learners’ cognitive processing rather than providing new information. It is one of the learning strategies that emphasizes the salient information of the content (Hannafin, Philips, Rieber & Garhart, 1987). In addition, it activates ideas that are closely related to the main concept and reduces the search for important ideas in multimedia environment.

Extensive studies have reported that using cuing improves conceptual recall (Meyer & Rice, 1982). However, effectively embedding cuing as an instructional strategy in the
computer-based environment is a challenge for instructional designers. Wager and Wager (1985) suggested considering the role of attention and encoding in cognitive processes may be one of the solutions. That is, using post-question as cuing can function for rehearsal purposes. Embedding cuing questions at the end of the instruction provides a “recency effect” that is closely connected to rehearsal (Kumar, 1971). In addition, Wager and Wager (1985) suggested several guidelines for using cuing questions based on existing research. For example, presenting salient cues with post questions can facilitate retention. Also, it is important to present relevant information meaningfully on the screen for students to select important information from a graphic.

Informational feedback, as reinforcement, is also important in the learning process. According to Skinner (1968), feedback affects learning significantly because if confirmation of one’s understanding is made at the beginning of learning it can strengthen learners understandings. The process of feedback is influenced by external stimuli that are “planned for the purpose of supporting learning” (Gagne, 1988, p. 38). Further, immediate feedback provides the opportunity for learners to explore the instruction deeper. If the learners get the answer incorrect, they may have the chance to review the instruction again. Wager and Wager (1985) suggested that this process can support knowledge construction more meaningfully. After answering questions, feedback helps learners to acquire specific information (Kemp et al., 1999). Thus, a cuing question with feedback was embedded as a post question in this study in order to provide learners an opportunity to rehearse their current understanding of the unit.
Animation in Multimedia Learning

Animation is “a series of varying images presented dynamically according to user action in ways that users perceive a continuous change over time and develop a more appropriate mental model of the task” (Gonzales, 1996, p. 7). Rieber (1990) proposed three unique functions in enhancing learning. First, attention gaining is a critical component in instruction (Gagne, 1985). Specifically, learning is enhanced when salient features of animation are closely connected to instruction. Second, animation can be structured with interactive activities to enable learners to elaborate upon their understandings of the concepts. In addition, animation provides practice opportunity for learners with immediate correction responses for “further reinforcement” (Rieber, 1990, p. 77). However, when using animation in instruction, two design issues need to be considered. Animation should be used when its dynamic features are substantially meaningful to learning (Rieber, 1990). That is, the animation should be designed based on learner needs, rather than adding cognitive load. Second, animation may not be an appropriate support to novice learners because they may not know how to attend the relevant information of the animation.

Recent studies have begun to examine animation functions from cognitive perspectives (Mayer 2003; Mayer & Mayer, 2003). For example, Mayer (2003) addressed limited working memory capacity. Integrating screen text and animation needs to be designed with care. In addition, Spiro and Jehng (1990) suggested that animation should be designed with meaningful representations to build the coherent understanding.
**Animated Agent**

An animated agent is considered to be a teaching assistant that provides pedagogical support and advice to promote meaningful learning. Specifically, research has focused on the animated agent for pedagogical uses (Baylor, 2002). According to Atkinson (2002), “the animated agent is a life-like character that can exploit instructional explanations as well as nonverbal forms of communication (e.g., gaze, gesture) within the examples themselves in an effort to promote a learners’ motivation toward the task and his or her cognitive engagement in it” (p. 416). It is suggested that designing an animated agent as an instructor like character, learners will be able to connect the animated agent with a real person and make an emotional attachment.

Similarly, Maes (1997) suggested that the design of the animated agent should include mentoring functions and providing feedback to learners. Later, Baylor and Kim (2006) proposed that the animated agent needs to be designed to share learner’s cognition to support learner performance of the tasks. For example, the animated agent should be designed as a competent tutor to assist learners (Chee, 1994).

In addition, based on existing research, there is no consensus on where to locate the animated agent. In Lester and colleagues (1997) research, the image of the animated agent appears on the bottom left corner of the screen where it presented problems to students. Alternatively, Atkinson (2002) placed the animated agent on the right side of the screen to provide mathematics solutions for students. Although current studies have not explored whether the location of the animated agent is a factor in a multimedia environment, it is suggested that considering the location of the animated agent will be important.
With regard to learning performance, the potential effects of an animated agent were examined in particular multimedia designs across different content domains (Baylor, 2002; Mayer, 2003; Mayer & Anderson 1991). These multimedia studies were mainly focused on the animated agent as a mediator between the content and learners. But the question still remains: which functions of an animated agent best support student learning most? From an educational perspective, animated agents provide contextualized advice and “observe” student progress. Mayer and Mayer (2003) claimed that the animated agent can provide individual feedback and support learners through emotional connection. This individual learning experience should encourage them to have a positive attitude toward learning. In addition, Baylor (2002) asserted that the animated agent can provide scaffolding in order facilitate learners’ construction of knowledge. It is suggested that through scaffolding, animated agents can provide instructional scaffolding strategies to promote understanding (Baylor & Kim, 2006).

It is hypothesized that learners will increase their motivation and comprehend the instruction more coherently by interacting with an animated agent that provides scaffolding.

**Functions of An Animated Agent**

Research studies have shown that the functional design of the animated agent can have a positive effect on student perceptions of their learning and increase their motivation (Atkinson, 2002; Baylor, 2002; Lester et al., 1997). An animated agent can also reduce the difficulty level of the instruction, by providing guided feedback and pointing to important concepts (Laurel, 1990; Moreno et al., 2000). In addition, a
learner’s prior knowledge of the domain can be stimulated and knowledge construction supported by an animated agent that provides elaborative prompts. This process is particularly important for novice learners because they lack sufficient schema to guide them in the selection of relevant cues to connect their current knowledge with new information. Mayer (2005) also suggested using animated agent from a social cognitive apprenticeship perspective can support learning gradually.

Based on existing research on the design of the animated agent (Atkinson, 2002, Baylor, 2002, Lester et al., 1997), two features of the animated agent were designed in this study. First, the animated agent provided feedback through cuing questions with feedback. Second, the animated agent provided instructional explanations.

*Educational Application for Field Dependence/Independence*

The concept of field dependence/independence has been studied for years and involves perceptual differences in individuals. Witkin and his colleagues (1962) created field dependent/independent measures of how individuals approach and perceive stimuli (Goodenough, 1976; Goodenough & Karp, 1961). A field dependent learner is defined as an individual who perceives the field globally and “tend[s] to be more socially oriented” (Goodenough, 1976, p. 684). In contrast, a field independent learner is defined as an individual who is more analytic in processing the stimuli and tends to be more internally motivated (Goodenough, 1976).

A critical factor in distinguishing field dependent/independent learners is their perception of the learning environment as the whole (Riding & Cheema, 1991). Extensive research suggests that field dependence/independence does affect learning (Moore&
Dwyer, 1991). Witkin, Moore, Goodenough, and Cox (1977) defined four major implications. First, cue salience affects learning concepts. With the aid of salient cues, field dependent learners are more likely to perceive details. In light of this difference and relevance in perceiving salient cues, field dependent learners are more likely to create a global picture of the information and approach the task holistically. On the other hand, field independent learners tend to focus on details in learning. Because empirical evidence suggests that field dependent learners tend not to perceive relevant cues in the initial learning process, it is suggested that cues may be an effective strategy to use for teaching concepts to field dependent learners (Bruner, Goodnow & Austin, 1956).

Second, the use of mediators in learning is another factor to consider. Field dependent learners are more likely to perceive the context as it is without using mediators to analyze structure than are field independent learners. However, instructional materials are often ill-structured or not well-structured. Additional enhancement such as rehearsal or elaboration, may be effective for field dependent learners for deeper, semantic processing. Further, Goodenough (1976) suggested that field independent learners tend to play an active role in imposing a mnemonic structure to organize materials. Last, social orientation is another factor that affects learning. Research suggests that field dependent learners are more attentive to social aspects from the environment than field independent learners.

In addition, based on these implications, Jonassen and Grabowski (1993) identified several instructional strengthens of field independent learners, such as extracting useful cues, evaluating and transferring knowledge into similar content, etc. On the other hand,
field dependent learners prefer to learn the materials with clear structure, cues and feedback.

Thus, understanding how field independent/dependent learners perceive instruction was critical to this study because bridging instructional treatments with field dependence/independence characteristics may affect their learning in a meaningful way. That is, field dependent learners may perform better with an animated pedagogical agent that provides cuing question with feedback than field independent learners because of the social nature of the animated agent and salient cues provided by the instructional scaffolding strategies.

**Summary**

The theoretical framework for this study was structured on the information processing model. Specifically, by focusing on learners’ attention and reducing cognitive load, an animated agent that provides scaffolding may encourage rehearsal and elaboration. Because the effectiveness of cognitive processes depends on instructional scaffolding strategies used, a story mnemonic and cuing question with feedback was predicted to facilitate cognitive processes in terms of levels of processing (Anderson & Shiffrin, 1968). Story mnemonic as an instructional strategy was selected to stimulate elaboration processing because it can help learners produce significant associations needed to connect existing knowledge with new information. Alternatively, rehearsal enhances retention of the information in short-term memory so that it may be transferred to long-term memory. The research also addressed how field dependent/independent learners perceive instruction differently with animated agent supports. It was
hypothesized that field dependent learners will perform better with the animated agent due to its social nature and the salient cues provided by the instructional scaffolding strategies. Alternatively, field independent learners may benefit from the story mnemonic strategy because it facilitates comprehension by having learners link details in a holistic story.
Chapter 3

Methods and Procedures

Introduction

The purpose of this study was to examine the effects of an animated agent that provides instructional scaffolding strategies via a story mnemonic or cuing questions with feedback versus instructional scaffolding strategies alone on student achievement of different educational objectives in multimedia learning. Specifically, the study investigated the effects of two animated agent conditions (with an animated agent, without an animated agent) with two instructional scaffolding strategies (story mnemonic and cuing questions with feedback) on knowledge and comprehension when controlling prior knowledge and field dependence/independence in multimedia learning.

In order to understand the effects of the animated agent with instructional scaffolding strategies precisely, a preliminary pilot test was conducted to determine difficult concepts within the instruction. The pilot test was followed by a design-based assessment study, to examine the animated agent using two types of prompts (verbal and visual prompts) in order to facilitate learning. Finally, the design based assessment was followed by the main study to examine the effects of the animated agent with instructional scaffolding strategies.
Preliminary Pilot Test

Purpose

The purpose of the preliminary pilot test was to identify the difficult concepts of instruction in order to identify places in the instructional materials that could be strengthened with an intervention to improve learner understanding. Difficult concepts within the instruction were found by using item analysis for each test.

Subjects

Twenty-five participants were recruited from an introductory educational psychology course at northeast university during summer 2006. The course had freshmen from different education majors. Students were invited to participate in the study and received extra points from the instructor.

Outcomes

Based on 25 participants’ scores from the preliminary pilot test, 22 items from a total of 40 items were identified as difficult -below .50 for answering each test item correctly. The difficult items indicated instructional interventions were needed in order to improve learning. Table 3.1 shows the preliminary pilot test analysis.
Table 3.1
Preliminary Pilot Test Analysis

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</tbody>
</table>

Thus, nine instructional screens taught facts tested by the difficult items (2, 3, 4, 5, 6, 8, 9, 12, 14) from the terminology test. Seven instructional screens taught concepts tested by difficult items from the comprehension test (6, 7, 8, 12, 14, 17, 20). Four of these instructional screens contained content tested by the difficult items from both the terminology and comprehension tests (6, 8, 12, 14). Thus, twelve instructional screens had the potential for improvement (see Table 3.2)
Because the instructional screens contained overlapping terminology and comprehension concepts, instructional interventions needed to be based on the main idea of the screen.
Design-based Assessment Study

An iterative design process testing the combination of theories and instructional designer advice informs the researcher about nuances of the design (Edelson, 2002). In addition, through design based assessment, an intervention can be improved based on testing and revision. In turn, the findings from a design-based assessment study can shape the main study into a more practical and effective one (Dede, 2005).

Purpose

The purpose of this design-based assessment study was to test the effects of the animated agent that provided verbal and visual prompts to facilitate learning in a multimedia environment. Specifically, it tested the effects of an animated agent that provided two types of pedagogical supports on knowledge and comprehension. This study did not isolate the effect of the animated agent.

Subjects

Sixty-seven participants were recruited from three different sections of an introductory educational psychology course at a northeast university during fall 2006. The course attracts freshmen from different education majors. Students were invited to participate in the study and received extra points from the instructor.
Instructional Materials

The computer-based instruction was adapted from paper-based instructional materials developed by Dwyer and Lamberski (1977). The instruction consisted of 20 computer screens with an 1,800-word narrative on the human heart and its functions. The instruction was structured from facts about the human heart, locations of the parts of the heart and their respective functions. It was developed according to a hierarchy of instructional objectives (Dwyer & Lamberski, 1977).

Instructional Treatments

Two treatments were developed, verbal prompt and visual prompt. An instructional intervention was placed on twelve instructional screens with the animated agent providing verbal and visual prompts (see Table 3.3).

Table 3.3 Instructional Treatments

<table>
<thead>
<tr>
<th>Instructional screen #</th>
<th>Verbal prompt</th>
<th>Visual prompts(with pictures)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Apex is the lower portion of the heart</td>
<td>It is the lower portion of the heart and is the part that you feel beating.</td>
</tr>
<tr>
<td>3</td>
<td>Auricles have thin walls and received rooms for the blood</td>
<td>The upper chambers on each side of the septum are called auricles.</td>
</tr>
<tr>
<td>4</td>
<td>Myocardium controls the contraction and relaxation of the heart.</td>
<td>Myocardium constitutes by far the greatest volume of the heart and its contraction is responsible for the propulsion of the blood through the body.</td>
</tr>
<tr>
<td>5</td>
<td>Superior vena cava deposits blood into the right auricle from all body parts.</td>
<td>Blood from the body enters the heart through superior vena cava.</td>
</tr>
<tr>
<td>6</td>
<td>Tricuspid valves permit the flow of blood into the right ventricle</td>
<td>This common opening, between the right auricle and the right ventricle, is called the tricuspid valves.</td>
</tr>
<tr>
<td>7</td>
<td>Pulmonary artery carried away the blood from the heart to the lungs.</td>
<td>Pulmonary artery is located between the right ventricle and the pulmonary valve.</td>
</tr>
<tr>
<td>8</td>
<td>Mitral valve located between the left auricle</td>
<td>Mitral valve has the similar function in construction to the tricuspid valve</td>
</tr>
</tbody>
</table>
and the left ventricle,

<table>
<thead>
<tr>
<th>9</th>
<th>Aorta is the artery which carries the blood away from the heart</th>
<th>It is the large artery that carries the blood away from the heart back to the body.</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Tricuspid valves is partially closed, when ventricles fill</td>
<td>As the ventricles fill, tricuspid valves back to partially closed position.</td>
</tr>
<tr>
<td>14</td>
<td>Pulmonary valve is leading from the right ventricle and guards the entrance to the pulmonary artery.</td>
<td>As the ventricles continue to contract, pressure in these chambers force pulmonary valve to open.</td>
</tr>
<tr>
<td>17</td>
<td>Auricle pressure fully opens the tricuspid and mitral valves.</td>
<td>Auricle pressure is resulted in a rapid flow of blood into the ventricles.</td>
</tr>
<tr>
<td>20</td>
<td>The second contraction begins when the auricles contract.</td>
<td>The second contraction is occurring when the tricuspid is forced to partially open.</td>
</tr>
</tbody>
</table>

Instructional materials for a control group were also developed.

**Control Group**

The control group received the instruction with on screen text and pictures relating to the human heart and its function without an animated agent presenting any verbal or visual prompts (see Figure 3.1).

![Figure 3.1. Control group](image)
**Treatment 1: Verbal prompt**

The verbal prompts treatment contained verbal explanations within the instructional unit. Verbal prompts were presented by an animated agent when students clicked the “Tell me” button. When learners clicked the button, a dialogue box was presented that contained explanations of the main concepts presented (see Figure 3.2).

![Figure 3.2. Verbal prompt sample screen](image)

**Treatment 2: Visual prompt**

The visual prompts treatment contained visual explanations within the instructional unit. Visual prompts were presented with an animated agent via the “Show me” button. When learners clicked on the button, a dialogue box was presented that contained pictorial explanations of the main concepts presented (see Figure 3.3).
Knowledge was measured by the terminology test developed by Dwyer and Lamberski (1977) and consisted of 20 multiple-choice items designed to measure knowledge of facts, terms, and definitions of the parts of the heart (see Appendix B). The reliability of the terminology test was .525.

Comprehension was measured by the comprehension test developed by Dwyer and Lamberski (1977) and consisted of 20 multiple-choice items that measured understanding of the functions and interrelationships among the parts of the heart (see Appendix C). The reliability of the comprehension test was .503.
Results of the Design-based Assessment Study

The difference among the three treatment groups was analyzed using analysis of variance (ANOVA) (see Table 3.4). Treatment effects were found for comprehension but not for knowledge. Pairwise comparison revealed that the visual prompts group outperformed the verbal group and the control group.

Table 3.4
Analysis of Variance Summary of Knowledge and Comprehension

<table>
<thead>
<tr>
<th>Criterion measures</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>2</td>
<td>36.25</td>
<td>1.94</td>
<td>.153</td>
</tr>
<tr>
<td>Comprehension</td>
<td>2</td>
<td>82.11</td>
<td>4.79</td>
<td>.012*</td>
</tr>
</tbody>
</table>

*Significant at the 0.05 level

Table 3.5 shows means and standard deviations for the treatment groups.

Table 3.5
Means and Standard Deviation of Treatment Groups

<table>
<thead>
<tr>
<th>Treatment Groups</th>
<th>Knowledge</th>
<th></th>
<th>Comprehension</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of items</td>
<td>M</td>
<td>S.D.</td>
<td>n</td>
</tr>
<tr>
<td>Control</td>
<td>20</td>
<td>9.62</td>
<td>4.11</td>
<td>13</td>
</tr>
<tr>
<td>Verbal prompts</td>
<td>20</td>
<td>9.13</td>
<td>4.64</td>
<td>24</td>
</tr>
<tr>
<td>Visual prompts</td>
<td>20</td>
<td>11.38</td>
<td>4.14</td>
<td>29</td>
</tr>
</tbody>
</table>
Changes in the Main Study

Five main changes were made to the design-based assessment study for the main study (see Table 3.6).

1. Based on the empirical data, no significant effect was found for verbal prompts. This may have been due to the fact that verbal explanations were not sufficient to support learner comprehension of the main concepts of the unit. Thus, they were replaced with a story mnemonic as an opportunity for learners to elaborate on the concepts. Providing keywords and asking learners to create their own stories may allow them to elaborate on their understanding and process factual knowledge more deeply.

2. Visual prompts provided through the animated agent were designed to guide learning. Although the result of the design-based assessment study showed more benefits for the visual prompt group than other groups, this was an opportunity to test other instructional scaffolding strategies presented by an animated agent. Cuing question with feedback was selected because it was predicted that having salient cues pointed out with practice opportunities would promote rehearsal and improve learning.

3. The design-based assessment study used terminology and comprehension tests to measure learner performance. However, prior knowledge was not tested but could be one factor that influenced learning. Therefore, an assessment of prior knowledge was added to the main study.

4. In multimedia learning, information may be presented with multiple supports in order to accommodate individual differences. Thus, another variable-field dependence/independence was added to understand how field dependent/independent learners
perceive the information differently through two types of instructional scaffolding strategies.

5. The design-based assessment study only examined the main effect of two types of prompts used with an animated agent. It did not isolate the effects of the animated agent. Thus, an animated agent condition was added to the main study. By isolating the effects of the animated agent, the researcher would be able to understand whether differences were due to the animated agent or instructional scaffolding strategies.

<table>
<thead>
<tr>
<th>Major change</th>
<th>Design-based assessment study</th>
<th>Main study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional scaffolding strategies</td>
<td>Verbal prompts, Visual prompts</td>
<td>Story mnemonic, Cuing question with feedback</td>
</tr>
<tr>
<td>Measurements</td>
<td>Knowledge and Comprehension</td>
<td>Prior knowledge and GEFT Knowledge and Comprehension</td>
</tr>
<tr>
<td>Test the effect of the animated agent</td>
<td>None</td>
<td>With the presence of the animated agent, Without the presence of the animated agent</td>
</tr>
</tbody>
</table>
The Main Study

Subjects

One hundred and twenty-seven participants were recruited from two different sections of an introductory engineering course at a northeast university during fall 2007. The course attracts freshmen from different majors. Students were invited to participate in the study and received extra points from the instructor.

Instructional Materials

The 1800 word computer based instruction materials were the same as those for the design-based assessment study.

Instructional Treatments

Four treatments were developed.

1. story mnemonic only
2. story mnemonic with the animated agent
3. cuing question with feedback only
4. cuing question with feedback with the animated agent

Directions for how to use the story mnemonic or cuing questions was provided for all treatment groups (see Appendix E, F, G, H). Each treatment contained 20 instructional screens of which 12 instructional screens contained instructional interventions (see Table 3.7). Twelve keywords and a cuing question with feedback were generated based on the main concepts of the twelve instructional screens.
<table>
<thead>
<tr>
<th>Instructional screen #</th>
<th>Keyword &amp; Explanations</th>
<th>Cuing question with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Apex: The lower portion of the heart</td>
<td>The lower portion of the heart is called?</td>
</tr>
<tr>
<td>3</td>
<td>Auricles: The upper chambers on each side of the septum</td>
<td>The upper chambers on each side of the septum are called?</td>
</tr>
<tr>
<td>4</td>
<td>Myocardium: controls the contraction and relaxation of the heart</td>
<td>What part of the heart controls the contraction and relaxation?</td>
</tr>
<tr>
<td>5</td>
<td>Superior vena cava: deposits blood into the right auricle from body parts above heart</td>
<td>Which vein deposits blood in the right auricle?</td>
</tr>
<tr>
<td>6</td>
<td>Tricuspid valve: Between the right auricle and the right ventricle</td>
<td>The common opening between the right auricle and the right ventricle is called?</td>
</tr>
<tr>
<td>7</td>
<td>Pulmonary artery: blood is carried away from the heart to both the left and right lungs</td>
<td>Which part carried away from the heart to the lung?</td>
</tr>
<tr>
<td>8</td>
<td>Mitral valve: located between the left auricle and the left ventricle</td>
<td>Which valve is the between the between the left auricle and the left ventricle?</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>9</td>
<td>Aorta: carries the blood away from the heart</td>
<td>Which is the large artery that carries the blood away from the heart back to the body?</td>
</tr>
<tr>
<td>12</td>
<td>Tricuspid valves: As the ventricles fill, it is closed position.</td>
<td>When ventricles fill, which part is closed?</td>
</tr>
<tr>
<td>14</td>
<td>Pulmonary valve: guards the entrance to the pulmonary artery</td>
<td>Which part guards the entrance to the pulmonary artery?</td>
</tr>
<tr>
<td>17</td>
<td>Auricle pressure: opens the tricuspid and mitral valves.</td>
<td>Which pressure opens the tricuspid and mitral valves?</td>
</tr>
<tr>
<td>20</td>
<td>The second contraction: the tricuspid valves are forced partially open.</td>
<td>What phase is occurring when the tricuspid valves are forced partially open?</td>
</tr>
</tbody>
</table>

_Treatment 1: Story mnemonic only_

The first treatment group contained 12 treatments with keywords and explanations displayed. Participants could click on the keyword button to display the unit keyword (see Figure 3.4). After clicking the button, the keyword was presented and contained the explanation (see Figure 3.5). At the end of the instruction, participants clicked on the “ready to create your story” button on screen 20. Then the story mnemonic screen
provided the description of how to create their stories (see Figure 3.6). After reading the description, participants were asked to create the story in Microsoft Word from 12 keywords (see Appendix I).

**Figure 3.4.** Keyword screen (instructional screen #3)

**Figure 3.5.** After clicking on keyword (instructional screen #3)
Treatment 2: Cuing question with feedback only

The second treatment received 12 cuing questions with feedback without the presence of the animated agent. Participants had the option of clicking on “show me” button (see Figure 3.7) at the bottom of the instructional screens. When learners clicked on the “show me” button, a cuing question was displayed beside an illustration of the heart with a part of the heart circled (see Figure 3.8). If participants clicked on the incorrect answer, the computer provided incorrect feedback (see Figure 3.9). If participants clicked on the correct answers, the computer provided correct feedback (see Figure 3.10).
Figure 3.7. Cuing question with feedback (instructional screen #5)

Figure 3.8. After clicking on cuing question (instructional screen #5)
Treatment 3: Story mnemonic in the presence of the animated agent

The third treatment contained 12 key words and an animated agent. The treatment was similar to treatment one, except for the presence of the animated agent. The animated
agent was placed at the bottom left and held a moving heart in her hand. The learners had an option of clicking on the “keyword” button (see Figure 3.11). After clicking the button, the keyword was presented and contained an explanation of the keyword (see Figure 3.12). At the end of the instruction, participants clicked on “ready to create your own story” button. Then the story mnemonic screen presented the animated agent that provided guidance on how to create the story (see Figure 3.13). Participants were asked to create their own stories in Microsoft Word.

![Figure 3.11. Story mnemonic with the presence of the animated agent (instructional screen #3)](image)
Figure 3.12. Keyword explanation with the presence of the animated agent (instructional screen #3)

Figure 3.13. Creating a story with the presence of the animated agent (at the end of the instruction)
**Treatment 4: Cuing question with feedback with the presence of the animated agent**

The fourth treatment contained 12 cuing questions with feedback with the presence of the animated agent. The treatment was similar to treatment two, except for the presence of the animated agent. The animated agent was placed at the bottom left of the screen and held a moving heart in her hand. Learners had an option of clicking on the “show me” button (see Figure 3.14). Upon clicking the “show me” button, a cuing question was displayed beside an illustration of the heart with a part of the heart circled (see Figure 3.15). Once participants clicked on the correct answer, the animated agent generated the correct answer feedback for further reinforcement (see Figure 3.16). If the participants clicked on an incorrect answer, a static pointer appeared in the animated agent’s hand, and incorrect feedback was displayed (see Figure 3.17).

*Figure 3.14. Cuing question with the presence of the animated agent (instructional screen #4)*
Figure 3.15. After clicking on cuing question with the presence of the animated agent (instructional screen #4)

Figure 3.16. Animated agent providing correct answer feedback (instructional screen #4)
Research Design

Independent Variables

Two independent variables were examined in this study: instructional strategies and animated agent conditions. Each variable had two levels. Instructional strategies in this study included story mnemonic and cuing question with feedback. Animated agent conditions included the presence and absence of the animated agent.

Dependent Variables

Two dependent variables were used to measure student achievement of different educational objectives: knowledge and comprehension.
Covariates

Prior knowledge and field dependence/independence were potential covariates in the main study. If the covariates were not found to be significant predictors, the covariates would then be used as independent variables.

Measurement Instruments

Field Dependence/Independence

GEFT, as a measure of field dependence/independence, was developed by Witkin and his colleagues (1971). GEFT contains three sections and has 26 complex figures items. The first section contains 7 simple items and is provided as practice. The second and third sections each contain 9 more difficult items. Participants were asked to locate the hidden figure in an embedded picture. The total score is the total number of correct items from the second and third sections. The scores can range from 0 to 18. The reliability of GEFT is estimated by the Spearman Brown formula and is .82. In addition, Witkin Otlnab and Raskin (1971) correlated the Embedded Figure test (EFT) to estimate validity. For female undergraduates, the correlation between GEFT and EFT was -.63. On the other hand, the correlation for male undergraduates was -.82. Scores of 11 or less indicate field dependent learning style. On the other hand, scores of 12 or greater indicate field independent learning style.

Prior Knowledge

The human physiology test developed by Dwyer (1972) tests prior knowledge and consists of 36 multiple-choice items (see Appendix A). After the initial reliability analysis, test items that had an item effect below .20 were ineffective for precise
measuring of participants’ prior knowledge and did not contributed to the internal consistency of the scale. Therefore, 21 items were deleted from original prior knowledge test (see Table 3.8). The total score for the revised prior knowledge test was 15. Cronbach’s alpha for this revision of the test was .626, which is an acceptable reliability for research (Cronbach, 1984).

Table 3.8
Analysis for Prior Knowledge

<table>
<thead>
<tr>
<th>Item number</th>
<th>Item effect</th>
<th>Item number</th>
<th>Item effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.32</td>
<td>19</td>
<td>0.17</td>
</tr>
<tr>
<td>2</td>
<td>0.07</td>
<td>20</td>
<td>0.26</td>
</tr>
<tr>
<td>3</td>
<td>-0.08</td>
<td>21</td>
<td>-0.35</td>
</tr>
<tr>
<td>4</td>
<td>0.01</td>
<td>22</td>
<td>0.56</td>
</tr>
<tr>
<td>5</td>
<td>0.62</td>
<td>23</td>
<td>-0.35</td>
</tr>
<tr>
<td>6</td>
<td>0.46</td>
<td>24</td>
<td>0.23</td>
</tr>
<tr>
<td>7</td>
<td>0.17</td>
<td>25</td>
<td>-0.07</td>
</tr>
<tr>
<td>8</td>
<td>0.22</td>
<td>26</td>
<td>0.19</td>
</tr>
<tr>
<td>9</td>
<td>0.01</td>
<td>27</td>
<td>0.07</td>
</tr>
<tr>
<td>10</td>
<td>-0.26</td>
<td>28</td>
<td>0.17</td>
</tr>
<tr>
<td>11</td>
<td>-0.07</td>
<td>29</td>
<td>0.11</td>
</tr>
<tr>
<td>12</td>
<td>0.29</td>
<td>30</td>
<td>0.47</td>
</tr>
<tr>
<td>13</td>
<td>0.59</td>
<td>31</td>
<td>-0.16</td>
</tr>
<tr>
<td>14</td>
<td>0.38</td>
<td>32</td>
<td>0.20</td>
</tr>
<tr>
<td>15</td>
<td>0.28</td>
<td>33</td>
<td>-0.07</td>
</tr>
<tr>
<td>16</td>
<td>0.10</td>
<td>34</td>
<td>-0.03</td>
</tr>
<tr>
<td>17</td>
<td>-0.05</td>
<td>35</td>
<td>-0.02</td>
</tr>
<tr>
<td>18</td>
<td>0.23</td>
<td>36</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Knowledge

Knowledge was measured by the terminology test designed by Dwyer (1972). This test consists of 20 multiple-choice items that measure knowledge of facts, terminology, and definitions of the heart. Based on the preliminary pilot test analysis, items were categorized as associated with manipulated screens (those screens containing the instructional intervention), and items associated with non-manipulated screens (those screens without the instructional intervention). Twelve items associated with manipulated
screens were identified and scored with one point each, for a total of 12 points (see Appendix B). Alternatively, 8 items associated with non-manipulated screens were scored with one point each for a total of 8 points. Table 3.9 shows the Kuder-Richardson-20 (KR-20) reliability coefficient for items associated with manipulated and non-manipulated screens, respectively.

Table 3.9
The Reliability Coefficients for Knowledge

<table>
<thead>
<tr>
<th>Items</th>
<th>Number of items</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Items associating with manipulated screens</td>
<td>12</td>
<td>.438</td>
</tr>
<tr>
<td>Items associating with non-manipulated screens</td>
<td>8</td>
<td>.387</td>
</tr>
</tbody>
</table>

**Comprehension**

Comprehension was measured by the comprehension test understandings and designed by Dwyer (1972). This test consists of 20 multiple-choice items. The purpose of the comprehension is to measure understanding of the heart, its function and the internal process during the systolic phase (Dwyer, 1972). Based on the preliminary pilot test analysis, items were categorized as items associated with manipulated screens (those screens containing the instructional intervention), and items associated with non-manipulated screens (those screens without the instructional intervention). Ten items associated with manipulated screens were identified and scored with one point each, for a total of 10 points (see Appendix C). Alternatively, 10 items associated with non-manipulated screens were scored with one point each for a total of 10 points. Table 3.10 shows the Kuder-Richardson-20 (KR-20) reliability coefficient for items associated with manipulated and non-manipulated screens, respectively.
Table 3.10
*The Reliability Coefficients for the Comprehension Test*

<table>
<thead>
<tr>
<th>Items</th>
<th>Number of items</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Items associating with manipulated screens</td>
<td>10</td>
<td>.303</td>
</tr>
<tr>
<td>Items associating with non-manipulated screens</td>
<td>10</td>
<td>.488</td>
</tr>
</tbody>
</table>

*Procedures*

Before starting the experiment, participants were asked to draw colored paper from a box of four colors in an order that led to random assignment. Each computer was labeled with blue, yellow, red, and purple colors to match the color in the box. Students were directed to find a computer with a color that matched the colored paper that they drew. Once participants were seated in front of the computer, they were asked to sign the informed consent form (see Appendix D) before participating in the study.

The experiment had two stages. First, participants were asked to take the Group Embedded Figures Test (GEFT), followed by the human physiology test. After completing both tests, the researcher explained the experimental procedures and answered questions from participants. Participants received directions from an individual file and then proceeded at their own pace through the instruction. After completing the instruction, participants were asked to take the terminology and comprehension tests in a paper-pencil format in order to complete the experiment. After finishing both tests, they were asked to log off the computer and leave the lab quietly.
Data Analysis

Multivariate analysis of covariance (MANCOVA) with prior knowledge as a covariate was run in order to understand the effects of the animated agent conditions (the animated agent present, the animated agent absent) and instructional scaffolding strategies (story mnemonic, cuing question with feedback) and an interaction between animated agent conditions and instructional strategies on knowledge and comprehension. In addition, analysis of covariance was conducted to understand the effects of the field dependence/independence, animated agent conditions and instructional scaffolding strategies on knowledge and comprehension when controlling for prior knowledge. All statistical tests used the .05 level for significance. The Bonferroni follow-up test was used to find the significant differences among treatment groups.
Chapter 4

Results

The purpose of this study was to examine the effects of an animated agent that provides instructional scaffolding strategies via a story mnemonic or cuing questions with instructional feedback versus instructional scaffolding strategies alone on student achievement of different educational objectives in multimedia learning. Specifically, the study investigated the effects of two animated agent conditions (with an animated agent, without an animated agent) with two instructional scaffolding strategies (story mnemonic and cuing questions with feedback) on knowledge and comprehension when controlling prior knowledge and field dependence/ independence (field independence/dependence) in multimedia learning.

Descriptive Analysis

Field Dependence/Independence

The scores for field dependence/independence ranged from 0 to 18, with a median of 12, mean of 11.31, and standard deviation of 4.36. The mean and standard deviations on GEFT for each group are presented in Table 4.1.

<table>
<thead>
<tr>
<th>Instructional scaffolding strategies</th>
<th>Animated agent present</th>
<th>Animated agent absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>S.D</td>
</tr>
<tr>
<td>Story mnemonic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field dependence</td>
<td>6.64</td>
<td>3.46</td>
</tr>
<tr>
<td>Field independence</td>
<td>14.41</td>
<td>2.21</td>
</tr>
<tr>
<td>Cuing question with feedback</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field dependence</td>
<td>7.69</td>
<td>2.96</td>
</tr>
<tr>
<td>Field independence</td>
<td>14.59</td>
<td>1.80</td>
</tr>
</tbody>
</table>
Table 4.2 shows the number of the field dependent/ independent participants in each treatment group.

Table 4.2

*Distribution of Field Dependent/independent Participants by Animated Agent and Instructional Scaffolding Strategies*

<table>
<thead>
<tr>
<th>Animated agent present</th>
<th>Animated agent absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD</td>
<td>FI</td>
</tr>
<tr>
<td>Story mnemonic</td>
<td>14</td>
</tr>
<tr>
<td>Cuing question with feedback</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
</tr>
</tbody>
</table>

Field dependent learners are those who score lower than 11
Field independent learners are those who score higher than 11

**Prior Knowledge**

The scores for prior knowledge ranged from 1 to 15, with a median of 11, mean of 10.62, and standard deviation of 2.36. Table 4.3 shows the means and standard deviations of each group for prior knowledge.

Descriptively, Table 4.3 indicated that prior knowledge was fairly equally distributed except for the cuing question with feedback without the presence of the animated agent group, which had the lowest standard deviation among the groups.
Table 4.3

Means and Standard Deviations of Prior Knowledge

<table>
<thead>
<tr>
<th>Instructional scaffolding strategies</th>
<th>Animated agent present</th>
<th></th>
<th></th>
<th></th>
<th>Animated agent absent</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of items</td>
<td>M</td>
<td>S.D</td>
<td>n</td>
<td></td>
<td>Number of items</td>
<td>M</td>
<td>S.D</td>
</tr>
<tr>
<td>Story mnemonic</td>
<td>15</td>
<td>10.45</td>
<td>2.34</td>
<td>31</td>
<td>15</td>
<td>10.50</td>
<td>2.40</td>
<td>32</td>
</tr>
<tr>
<td>Cuing question with feedback</td>
<td>15</td>
<td>10.36</td>
<td>2.77</td>
<td>33</td>
<td>15</td>
<td>10.90</td>
<td>1.72</td>
<td>31</td>
</tr>
</tbody>
</table>

Knowledge and Comprehension

Knowledge and Comprehension from Manipulated Screens

Knowledge scores of those items associated with manipulated screens ranged from 0 to 12, with a median of 4, mean of 4.02 and standard deviation of 2.10. In addition, comprehension scores for test items associated with manipulated screens ranged from 0 to 10, with a median of 3, mean of 2.69 and standard deviation of 1.53.

Table 4.4 shows the means and standard deviations of each group for test items associated with manipulated screens on knowledge and comprehension.

Table 4.4

Means, Standard Deviations of Manipulated Items on Knowledge and Comprehension

<table>
<thead>
<tr>
<th>Instructional scaffolding strategies</th>
<th>Animated agent present</th>
<th></th>
<th></th>
<th></th>
<th>Animated agent absent</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number Of items</td>
<td>M</td>
<td>S.D</td>
<td>n</td>
<td></td>
<td>Number of items</td>
<td>M</td>
<td>S.D</td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story mnemonic</td>
<td>12</td>
<td>4.00</td>
<td>1.93</td>
<td>31</td>
<td>12</td>
<td>4.13</td>
<td>1.94</td>
<td>32</td>
</tr>
<tr>
<td>Cuing question with feedback</td>
<td>12</td>
<td>4.15</td>
<td>2.17</td>
<td>33</td>
<td>12</td>
<td>3.74</td>
<td>2.44</td>
<td>31</td>
</tr>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story mnemonic</td>
<td>10</td>
<td>2.45</td>
<td>1.43</td>
<td>31</td>
<td>10</td>
<td>2.81</td>
<td>1.60</td>
<td>32</td>
</tr>
<tr>
<td>Cuing question with feedback</td>
<td>10</td>
<td>2.39</td>
<td>1.50</td>
<td>33</td>
<td>10</td>
<td>3.12</td>
<td>1.59</td>
<td>31</td>
</tr>
</tbody>
</table>

The range of the knowledge was from 0 to 12
The range of the comprehension was from 0 to 10
Descriptively, Table 4.4 shows that knowledge scores were fairly equally distributed, except for the cuing question with feedback without the animated agent group. That group had the lowest mean scores among four treatment groups on the terminology test. Alternatively, on the comprehension test, test scores were also fairly equally distributed. With regard to the animated agent conditions, participants had higher mean scores when the animated agent was absent regardless of the instructional scaffolding strategies they used.

**Knowledge and Comprehension from Non-manipulated Screens**

Knowledge of those associated with non-manipulated screens ranged from 0 to 8, with a median of 3, mean of 3.54 and standard deviation of 1.69. Comprehension scores of those items associated with non-manipulated screens ranged from 0 to 10, with a median of 3, mean of 3.16 and standard deviation of 1.97.

Table 4.5 shows the means and standard deviations of each group for test items associated with non-manipulated screens on knowledge and comprehension.

<table>
<thead>
<tr>
<th>Instructional scaffolding strategies</th>
<th>Animated agent conditions</th>
<th>Knowledge</th>
<th>Comprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Animated agent present</td>
<td>M</td>
<td>S.D</td>
</tr>
<tr>
<td></td>
<td>Number of items</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story mnemonic</td>
<td>8</td>
<td>2.90</td>
<td>1.66</td>
</tr>
<tr>
<td>Cuing question with feedback</td>
<td>8</td>
<td>3.54</td>
<td>1.68</td>
</tr>
</tbody>
</table>

|                                      | Animated agent absent     | M         | S.D | n     |
|                                      | Number of items           |           |     |       |
| Story mnemonic                       | 10                        | 2.90      | 1.51 | 31    |
| Cuing question with feedback         | 10                        | 3.33      | 2.11 | 33    |

The range of the knowledge is from 0 to 8
The range of the comprehension is from 0 to 10
Hypotheses Testing

Six research hypotheses were examined in this study. The first hypothesis examined the whether prior knowledge would predict knowledge or comprehension. The second hypothesis examined whether field dependence/independence would predict knowledge or comprehension. Multiple regression was used to test correlations among the variables. The next three hypotheses examined the main effects of the animated agent conditions, instructional scaffolding strategies and an interaction between agent conditions and instructional scaffolding strategies respectively. Multivariate analysis of covariance (MANCOVA) was used to examine the variance of the independent variables in the fitted model. The last hypothesis examined the interaction between field dependent learners and field independent learners on animated agent conditions and instructional scaffolding strategies on knowledge and comprehension. Analysis of covariance (ANCOVA) was used to examine the interaction between field dependence/independence, animated agent conditions and instructional scaffolding strategies on knowledge and comprehension.

Prior Knowledge and Field Dependence/Independence

Ho1: Prior knowledge will not significantly predict knowledge or comprehension.

Ho 2: Field dependence/independence will not significantly predict knowledge or comprehension.

Hypotheses 1 and 2 were designed to determine whether field dependence/independence predicted knowledge or comprehension. Overall, the combined linear
effect of field dependence/independence and prior knowledge to knowledge and comprehension was statistically significant (Multiple R=.254, p=.024). In addition, the results indicated that the correlation between prior knowledge and knowledge was significant (p=.024). However, the correlation between field dependence/independence and knowledge was not significant (p=.553). In addition, the correlation between prior knowledge and comprehension was significant (p=.008). The correlation between field dependence/independence and comprehension was not significant as well (p=.652).

Table 4.6 shows multiple regression results and partial correlations between prior knowledge and knowledge, field dependence/independence and knowledge. Table 4.7 shows multiple regression results and partial correlations between prior knowledge and comprehension and field dependence/independence and comprehension.

Based on the multiple regression analysis, field dependence/independence was not a significant predictor of either knowledge or comprehension. Thus, field dependence/independence was not used as a covariate for hypotheses testing. It is clear that prior knowledge is a better predictor than field dependence/independence of knowledge and comprehension.

Table 4.6

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Beta</th>
<th>Partial Correlation</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field dependence/independence</td>
<td>-.025</td>
<td>.054</td>
<td>.553</td>
</tr>
<tr>
<td>Prior knowledge</td>
<td>.184</td>
<td>.202</td>
<td>.024</td>
</tr>
</tbody>
</table>
Table 4.7
*Multiple Regression Analysis for Field Dependence/Independence and Prior Knowledge with Comprehension*

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Beta</th>
<th>Partial Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field dependence/independence</td>
<td>-.014</td>
<td>-.014</td>
<td>.652</td>
</tr>
<tr>
<td>Prior knowledge</td>
<td>.155</td>
<td>.235</td>
<td>.008</td>
</tr>
</tbody>
</table>

*Animated Agent Conditions and Instructional Scaffolding Strategies*

Ho3: There will be no statistically significant differences between instructional scaffolding strategies on knowledge or comprehension.

Ho4: There will be no statistically significant differences between animated agent conditions on knowledge or comprehension.

Ho5: There will be no statistically significant interaction between animated agent conditions and instructional scaffolding strategies on knowledge or comprehension.

*Statistical Assumptions*

To use multivariate analysis of variance (MANCOVA), a normal distribution is assumed in which each group has equivalent variance. Levene’s test was run to test the assumption. The results showed that the variance for each group was not significantly different at the .05 alpha level for either knowledge or comprehension. Therefore, the assumption for equal variance among groups was met.

Table 4.8 shows that the correlation between knowledge and comprehension for the manipulated screens was significant. This intercorrelation of the dependent measures...
requires the use of MANOVA rather than two separate ANOVA for knowledge and comprehension. The same intercorrelation was found for knowledge and comprehension for the non-manipulated screens (see Table 4.9). Finally, because prior knowledge was a significant predictor of performance, MANCOVA was selected as the analysis method for these hypotheses.

Table 4.8
*Pearson Correlation Between Knowledge and Comprehension (Manipulated screens)*

<table>
<thead>
<tr>
<th>Valuable (Test)</th>
<th>Knowledge</th>
<th>Comprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Comprehension</td>
<td>.291**</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Correlation significant at the 0.01 level (2-tailed)**

Table 4.9
*Pearson Correlation Between Knowledge and Comprehension (Non-manipulated screens)*

<table>
<thead>
<tr>
<th>Valuable (Test)</th>
<th>Knowledge</th>
<th>Comprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Comprehension</td>
<td>.450**</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Correlation significant at the 0.01 level (2-tailed)**
Manipulated Screens

Knowledge

Table 4.10 shows the MANCOVA results for manipulated screens for knowledge. No significant differences were found between the animated agent conditions (F (1, 122) = .277, p = .600). There were no significant differences between instructional scaffolding strategies (F (1, 122) = .152, p = .697). Finally, there was no significant interaction between the animated agent conditions and instructional scaffolding strategies (F (1, 121) = .705, p = .403). Therefore, the null hypotheses 3, 4 and 5 were retained at the .05 significance level.

Table 4.10
MANCOVA of Knowledge on Items Associated with Manipulated Screens

<table>
<thead>
<tr>
<th>Source</th>
<th>Pillai’s Trace</th>
<th>F</th>
<th>Sig</th>
<th>Eta squared</th>
<th>Observed power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animated agent conditions</td>
<td>.037</td>
<td>.277</td>
<td>.600</td>
<td>.002</td>
<td>.082</td>
</tr>
<tr>
<td>Instructional scaffolding strategies</td>
<td>.004</td>
<td>.152</td>
<td>.697</td>
<td>.001</td>
<td>.067</td>
</tr>
<tr>
<td>Animated agent conditions * instructional scaffolding strategies</td>
<td>.012</td>
<td>.705</td>
<td>.403</td>
<td>.006</td>
<td>.133</td>
</tr>
<tr>
<td>Prior knowledge</td>
<td>.070</td>
<td>5.392</td>
<td>.022</td>
<td>.043</td>
<td>.634</td>
</tr>
</tbody>
</table>
Table 4.11 shows the adjusted means and standard errors by the animated agent conditions on knowledge when controlling for prior knowledge.

Table 4.11  
**Adjusted Means and Standard Errors by Animated Agent Conditions on Knowledge (Manipulated screens)**

<table>
<thead>
<tr>
<th>Test by animated agent conditions</th>
<th>Adjusted mean</th>
<th>Standard error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animated agent present</td>
<td>4.10</td>
<td>.262</td>
<td>3.585-4.622</td>
</tr>
<tr>
<td>Animated agent absent</td>
<td>3.91</td>
<td>.266</td>
<td>3.380-4.433</td>
</tr>
</tbody>
</table>

The range of the knowledge is from 0 to 12

Table 4.12 shows adjusted means and standard errors by instructional scaffolding strategies on knowledge when controlling for prior knowledge.

Table 4.12  
**Adjusted Means and Standard Errors by Instructional Scaffolding Strategies on Knowledge (Manipulated screens)**

<table>
<thead>
<tr>
<th>Test by instructional scaffolding strategies</th>
<th>Adjusted mean</th>
<th>Standard error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story mnemonic</td>
<td>4.08</td>
<td>.266</td>
<td>3.552-4.604</td>
</tr>
<tr>
<td>Cuing question with feedback</td>
<td>3.93</td>
<td>.262</td>
<td>3.414-4.451</td>
</tr>
</tbody>
</table>

The range of the knowledge is from 0 to 12
Comprehension

Multivariate analysis of covariance (MANCOVA) of comprehension yielded no significant effect for animated agent conditions when controlling for prior knowledge (F(1,122) = 3.508, p = .063). In addition, there were no significant differences between instructional scaffolding strategies (F(1, 122) = .172, p = .679). Further, there was no significant interaction between the animated agent conditions and instructional scaffolding strategies (F(1, 121) = .340, p = .561). Therefore, the null hypotheses 3, 4 and 5 were retained at the .05 significance level. Table 4.13 shows MANCOVA results for the animated agent conditions and instructional scaffolding strategies on comprehension.

Table 4.13
MANCOVA of Comprehension on Items Associated with Manipulated Screens

<table>
<thead>
<tr>
<th>Source</th>
<th>Pillai’s Trace</th>
<th>F</th>
<th>Sig</th>
<th>Eta squared</th>
<th>Observed power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animated agent conditions</td>
<td>.037</td>
<td>3.508</td>
<td>.063</td>
<td>.028</td>
<td>.459</td>
</tr>
<tr>
<td>Instructional scaffolding strategies</td>
<td>.004</td>
<td>.172</td>
<td>.679</td>
<td>.001</td>
<td>.070</td>
</tr>
<tr>
<td>Animated agent conditions * Instructional scaffolding strategies</td>
<td>.012</td>
<td>.340</td>
<td>.561</td>
<td>.003</td>
<td>.089</td>
</tr>
<tr>
<td>Prior knowledge</td>
<td>.070</td>
<td>6.253</td>
<td>.014</td>
<td>.049</td>
<td>.699</td>
</tr>
</tbody>
</table>
Table 4.14 shows the adjusted means and standard errors by the animated agent conditions on comprehension when controlling for prior knowledge.

Table 4.14
Adjusted Means and Standard Errors by Animated Agent Conditions on Comprehension (Manipulated screens)

<table>
<thead>
<tr>
<th>Test by animated agent conditions</th>
<th>Adjusted mean</th>
<th>Standard error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animated agent present</td>
<td>2.44</td>
<td>.188</td>
<td>2.073-2.816</td>
</tr>
<tr>
<td>Animated agent absent</td>
<td>2.95</td>
<td>.191</td>
<td>2.568-3.323</td>
</tr>
</tbody>
</table>

The range of the comprehension is from 0 to 10

Table 4.15 shows adjusted means and standard errors by instructional scaffolding strategies on comprehension when controlling for prior knowledge.

Table 4.15
Adjusted Means and Standard Errors by Instructional Scaffolding Strategies on Comprehension (Manipulated screens)

<table>
<thead>
<tr>
<th>Test by instructional scaffolding strategies</th>
<th>Adjusted mean</th>
<th>Standard error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story mnemonic</td>
<td>2.64</td>
<td>.190</td>
<td>2.262-3.016</td>
</tr>
<tr>
<td>Cuing question with feedback</td>
<td>2.75</td>
<td>.188</td>
<td>2.379-3.121</td>
</tr>
</tbody>
</table>

The range of the comprehension is from 0 to 10
Non-manipulated Screens

Knowledge

Multivariate analysis of covariance (MANCOVA) of knowledge yielded no significant effect for animated agent conditions when controlling for prior knowledge (F (1, 122) = 3.78, p = .054). In addition, the difference between the two instructional scaffolding strategies was not statistically significant (F (1, 122) = .447, p = .505). No significant interaction was found between the animated agent conditions and instructional scaffolding strategies (F (1, 122) = 2.73, p = .101). Table 4.16 shows the MANCOVA results on the animated agent conditions and instructional scaffolding strategies on knowledge. Therefore, the null hypotheses 3, 4 and 5 were retained at the .05 significance level.

Table 4.16
MANCOVA of Knowledge (Non-manipulated screens)

<table>
<thead>
<tr>
<th>Source</th>
<th>Pillai’s Trace</th>
<th>F</th>
<th>Sig</th>
<th>Eta squared</th>
<th>Observed power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animated agent conditions</td>
<td>.036</td>
<td>3.78</td>
<td>.054</td>
<td>.030</td>
<td>.487</td>
</tr>
<tr>
<td>Instructional scaffolding strategies</td>
<td>.007</td>
<td>.447</td>
<td>.505</td>
<td>.004</td>
<td>.102</td>
</tr>
<tr>
<td>Animated agent conditions * instructional scaffolding strategies</td>
<td>.023</td>
<td>2.731</td>
<td>.101</td>
<td>.022</td>
<td>.375</td>
</tr>
<tr>
<td>Prior knowledge</td>
<td>.091</td>
<td>11.637</td>
<td>.001</td>
<td>.087</td>
<td>.923</td>
</tr>
</tbody>
</table>
Table 4.17 shows the adjusted means and standard errors by the animated agent conditions on knowledge when controlling for prior knowledge.

Table 4.17
*Adjusted Means and Standard Errors by Animated Agent Conditions on Knowledge (Non-manipulated screens)*

<table>
<thead>
<tr>
<th>Test by animated agent conditions</th>
<th>Adjusted mean</th>
<th>Standard error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animated agent present</td>
<td>3.26</td>
<td>.200</td>
<td>2.858-3.651</td>
</tr>
<tr>
<td>Animated agent absent</td>
<td>3.81</td>
<td>.202</td>
<td>3.408-4.208</td>
</tr>
</tbody>
</table>

Table 4.18 shows adjusted means and standard errors for instructional scaffolding strategies on knowledge when controlling for prior knowledge.

Table 4.18
*Adjusted Means and Standard Errors by Instructional Scaffolding Strategies on Knowledge (Non-manipulated screens)*

<table>
<thead>
<tr>
<th>Test by instructional scaffolding strategies</th>
<th>Adjusted mean</th>
<th>Standard error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story mnemonic</td>
<td>3.44</td>
<td>.202</td>
<td>3.037-3.836</td>
</tr>
<tr>
<td>Cuing question with feedback</td>
<td>3.63</td>
<td>.200</td>
<td>3.230-4.023</td>
</tr>
</tbody>
</table>
Comprehension

Multivariate analysis of covariance (MANCOVA) yielded no significant main effect for the animated agent conditions on comprehension when controlling for prior knowledge (F (1, 122) =.001, p=.975). There was no significant main effect on instructional scaffolding strategies (F (1, 122) =.764, p=.384). In addition, no significant interaction was found between the animated agent conditions and instructional scaffolding strategies (F (1, 121) =.163 p=.687). Therefore, the null hypotheses 3, 4 and 5 were retained at the .05 significance level. Table 4.19 shows the MANCOVA results on the animated agent conditions and instructional scaffolding strategies on comprehension.

Table 4.19
MANCOVA of Comprehension (Non-manipulated screens)

<table>
<thead>
<tr>
<th>Source</th>
<th>Pillai’s Trace</th>
<th>F</th>
<th>Sig</th>
<th>Eta squared</th>
<th>Observed power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animated agent conditions</td>
<td>.036</td>
<td>.001</td>
<td>.975</td>
<td>.000</td>
<td>.050</td>
</tr>
<tr>
<td>Instructional scaffolding strategies</td>
<td>.007</td>
<td>.764</td>
<td>.384</td>
<td>.006</td>
<td>.140</td>
</tr>
<tr>
<td>Animated agent conditions * instructional scaffolding strategies</td>
<td>.023</td>
<td>.163</td>
<td>.687</td>
<td>.001</td>
<td>.069</td>
</tr>
<tr>
<td>Prior knowledge</td>
<td>.091</td>
<td>4.526</td>
<td>.035*</td>
<td>.036</td>
<td>.560</td>
</tr>
</tbody>
</table>
Table 4.20 shows the adjusted means and standard errors by animated agent conditions on comprehension when controlling for prior knowledge.

Table 4.20
*Adjusted Means and Standard Errors by Animated Agent Conditions on Comprehension (Non-manipulated Screens)*

<table>
<thead>
<tr>
<th>Test by animated agent conditions</th>
<th>Adjusted mean</th>
<th>Standard error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animated agent present</td>
<td>3.14</td>
<td>.245</td>
<td>2.656-3.626</td>
</tr>
<tr>
<td>Animated agent absent</td>
<td>3.15</td>
<td>.247</td>
<td>2.664-3.641</td>
</tr>
</tbody>
</table>

Table 4.21 shows adjusted means and standard errors for instructional scaffolding strategies on comprehension when controlling for prior knowledge.

Table 4.21
*Adjusted Means and Standard Errors by Instructional Scaffolding Strategies on Comprehension (Non-manipulated Screens)*

<table>
<thead>
<tr>
<th>Test by instructional scaffolding strategies</th>
<th>Adjusted mean</th>
<th>Standard error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story mnemonic</td>
<td>3.00</td>
<td>.247</td>
<td>2.507-3.483</td>
</tr>
<tr>
<td>Cuing question with feedback</td>
<td>3.30</td>
<td>.245</td>
<td>2.814-3.783</td>
</tr>
</tbody>
</table>
Field Dependence/Independence, Animated Agent and Instructional Scaffolding Strategies (Manipulated screens)

Ho6: There will be no statistically significant interaction between field dependent learners and field independent learners on animated agent conditions and instructional scaffolding strategies on knowledge or comprehension.

Knowledge

The last hypothesis examined the interaction between field dependent and field independent learners on animated agent conditions and instructional scaffolding strategies on knowledge and comprehension. The overall mean for field dependent learners on knowledge test associated with manipulated screens was 4.10, with a standard deviation of 1.88. Alternatively, the mean for field independent learners on this test was 3.93, with a standard deviation of 2.30.

Table 4.22 shows means and standard deviations for field dependent and field independent learner scores on knowledge by animated agent conditions and instructional scaffolding strategies.
Table 4.22
Means and Standard Deviation on Knowledge (Manipulated screens)

<table>
<thead>
<tr>
<th>Animated agent conditions</th>
<th>Instructional scaffolding strategies</th>
<th>Field dependence/ independence</th>
<th>M</th>
<th>Std.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animated agent present</td>
<td>Story mnemonic</td>
<td>Field dependence</td>
<td>3.43</td>
<td>1.87</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field independence</td>
<td>4.47</td>
<td>1.91</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Cuing question with feedback</td>
<td>Field dependence</td>
<td>4.06</td>
<td>1.44</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field independence</td>
<td>4.23</td>
<td>2.73</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Field dependence</td>
<td>3.77</td>
<td>1.65</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field independence</td>
<td>4.35</td>
<td>2.31</td>
<td>34</td>
</tr>
<tr>
<td>Animated agent absent</td>
<td>Story mnemonic</td>
<td>Field dependence</td>
<td>4.14</td>
<td>1.70</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field independence</td>
<td>4.11</td>
<td>2.18</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Cuing question with feedback</td>
<td>Field dependence</td>
<td>4.73</td>
<td>2.37</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field independence</td>
<td>2.81</td>
<td>2.16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Field dependence</td>
<td>4.45</td>
<td>2.06</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field independence</td>
<td>3.48</td>
<td>2.24</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>Story mnemonic</td>
<td>Field dependence</td>
<td>3.79</td>
<td>1.79</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field independence</td>
<td>4.29</td>
<td>2.02</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Cuing question with feedback</td>
<td>Field dependence</td>
<td>4.39</td>
<td>1.94</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field independence</td>
<td>3.55</td>
<td>2.54</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Field dependence</td>
<td>4.10</td>
<td>1.88</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field independence</td>
<td>3.93</td>
<td>2.30</td>
<td>67</td>
</tr>
</tbody>
</table>

The knowledge scores ranged from 0 to 12

Table 4.23 shows the results from the analysis of covariance on the animated agent conditions and field dependence/independence when controlling for prior knowledge. Analysis of covariance (ANCOVA) results yielded a significant interaction between animated agent conditions and field dependence/independence (p=.037). The interaction showed that field dependent learners performed higher than field independent learners when the animated agent was absent. Alternatively, field independent learners performed better than field dependent learners when the animated agent was present (see Figure 4.1). Therefore, the null hypotheses 6 were rejected at the .05 significance level.
Table 4.23
*Analysis of Covariance of Knowledge on Animated Agent Conditions, Field Dependence/Independence and Instructional Scaffolding Strategies*

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>Sig</th>
<th>Observed power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field dependence/independence</td>
<td>1</td>
<td>.469</td>
<td>.495</td>
<td>.403</td>
</tr>
<tr>
<td>Animated agent conditions</td>
<td>1</td>
<td>.174</td>
<td>.678</td>
<td>.070</td>
</tr>
<tr>
<td>Instructional strategies</td>
<td>1</td>
<td>.092</td>
<td>.762</td>
<td>.060</td>
</tr>
<tr>
<td>Animated agent conditions * field dependence/independence</td>
<td>1</td>
<td>4.465</td>
<td>.037*</td>
<td>.560</td>
</tr>
<tr>
<td>Field dependence/independence * Instructional strategies</td>
<td>1</td>
<td>2.990</td>
<td>.068</td>
<td>.403</td>
</tr>
<tr>
<td>Field dependence/independence * instructional strategies</td>
<td>2</td>
<td>.687</td>
<td>.505</td>
<td>.163</td>
</tr>
<tr>
<td>Field dependence/independence * animated agent conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior knowledge</td>
<td>1</td>
<td>5.16</td>
<td>.025</td>
<td>.616</td>
</tr>
</tbody>
</table>

*Probability significant at the 0.05 level

Table 4.24 shows the adjusted means for the animated agent conditions and field dependence/independence when adjusted for prior knowledge.

Table 4.24
*Adjusted Means for Animated Agent Conditions and Field Dependence/Independence*

<table>
<thead>
<tr>
<th>Animated agent conditions</th>
<th>Field dependence/independence</th>
<th>M</th>
<th>Std. Error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animated agent present</td>
<td>Field dependent</td>
<td>3.850</td>
<td>.375</td>
<td>3.109-4.592</td>
</tr>
<tr>
<td></td>
<td>Field independent</td>
<td>4.341</td>
<td>.350</td>
<td>3.649-5.034</td>
</tr>
<tr>
<td>Animated agent absent</td>
<td>Field dependent</td>
<td>4.470</td>
<td>.372</td>
<td>3.732-5.207</td>
</tr>
<tr>
<td></td>
<td>Field independent</td>
<td>3.314</td>
<td>.356</td>
<td>2.708-4.118</td>
</tr>
</tbody>
</table>
Figure 4.1. Estimated margins means for knowledge
**Comprehension**

The overall mean for field dependent learners on comprehension was 2.83, with a standard deviation of 1.62. Alternatively, the overall mean for field independent learners on comprehension was 2.52, with a standard deviation of 1.45.

<table>
<thead>
<tr>
<th>Table 4.25</th>
<th>Means and Standard Deviation on Comprehension (Manipulated screens)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Animated agent conditions</strong></td>
<td><strong>Instructional scaffolding strategies</strong></td>
</tr>
<tr>
<td><strong>Field dependence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Field independence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Field dependence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Field independence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Field independence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Animated agent absent</strong></td>
<td><strong>Story mnemonic</strong></td>
</tr>
<tr>
<td><strong>Field dependence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Field independence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Field independence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Field independence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Story mnemonic</strong></td>
</tr>
<tr>
<td><strong>Field dependence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Field independence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Field independence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
<tr>
<td><strong>Field independence</strong></td>
<td><strong>Field dependence</strong></td>
</tr>
</tbody>
</table>

Comprehension scores ranged from 0 to 10
Descriptively, with regard to animated agent conditions, field independent learners had higher mean scores than field dependent learners when the animated agent was present. Interestingly, when the animated agent was absent, field dependent learners had higher mean scores than field independent learners.

Table 4.26

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>Sig</th>
<th>Observed power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field dependence/independence</td>
<td>1</td>
<td>2.553</td>
<td>.113</td>
<td>.354</td>
</tr>
<tr>
<td>Animated agent conditions</td>
<td>1</td>
<td>4.238</td>
<td>.042</td>
<td>.533</td>
</tr>
<tr>
<td>Instructional strategies</td>
<td>1</td>
<td>.129</td>
<td>.720</td>
<td>.065</td>
</tr>
<tr>
<td>Animated agent conditions * Field dependence/independence</td>
<td>1</td>
<td>6.018</td>
<td>.016*</td>
<td>.682</td>
</tr>
<tr>
<td>Field dependence/independence * Instructional strategies</td>
<td>1</td>
<td>.341</td>
<td>.560</td>
<td>.089</td>
</tr>
<tr>
<td>Field dependence/independence * *instructional strategies * *animated agent conditions</td>
<td>2</td>
<td>.232</td>
<td>.794</td>
<td>.086</td>
</tr>
<tr>
<td>Prior Knowledge</td>
<td>1</td>
<td>7.761</td>
<td>.009*</td>
<td>.756</td>
</tr>
</tbody>
</table>

*Probability significant at the 0.05 level

Table 4.26 shows the results of the analysis of covariance on animated agent conditions and field dependence/independence when controlling for prior knowledge on comprehension. In addition, ANCOVA indicated significant main effect for animated agent conditions (p=.042). However, there were no significant main effects of field dependence/independence and instructional scaffolding strategies, respectively, on
comprehension. Analysis of covariance results yields a significant interaction between
the animated agent conditions and field dependence/independence. Therefore, the null
hypotheses 6 were rejected at the .05 significance level.

Table 4.27 shows adjusted means and standard deviations for the animated agent
conditions when controlling for prior knowledge on comprehension.

Table 4.27
_Adjusted Means and Standard Deviations by Animated Agent Conditions on
Comprehension_

<table>
<thead>
<tr>
<th>Test by animated agent conditions</th>
<th>Adjusted mean</th>
<th>Standard error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animated agent present</td>
<td>2.438</td>
<td>.184</td>
<td>2.075-2.802</td>
</tr>
<tr>
<td>Animated agent absent</td>
<td>2.975</td>
<td>.185</td>
<td>2.609-3.341</td>
</tr>
</tbody>
</table>

Table 4.28 shows adjusted means and standard deviations by animated agent
conditions and field dependence/independence when controlling for prior knowledge on
comprehension. The interaction showed that when the animated agent was absent, field
dependent learners scored significant higher than field independent learners. Second,
when the animated agent was absent, field dependent learners scored significantly higher
than field dependent learners when the animated agent was present (See Figure 4.2)

Table 4.28
_Adjusted Means and Standard Deviations between Animated Agent Conditions and Field Dependence/Independence on Comprehension_

<table>
<thead>
<tr>
<th>Animated agent conditions</th>
<th>Field dependence/ independence</th>
<th>M</th>
<th>Std. error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animated agent present</td>
<td>Field dependent</td>
<td>2.328</td>
<td>.269</td>
<td>1.796-2.859</td>
</tr>
<tr>
<td></td>
<td>Field independent</td>
<td>2.549</td>
<td>.251</td>
<td>2.052-3.046</td>
</tr>
<tr>
<td>Animated agent absent</td>
<td>Field dependent</td>
<td>3.503</td>
<td>.267</td>
<td>2.974-4.031</td>
</tr>
<tr>
<td></td>
<td>Field independent</td>
<td>2.447</td>
<td>.255</td>
<td>1.942-2.953</td>
</tr>
</tbody>
</table>
Figure 4.2. Estimated marginal means for comprehension
The study examined five research questions, testing six hypotheses in order to understand the effects of the animated agent conditions and instructional scaffolding strategies and their interactions, on knowledge and comprehension when controlling for prior knowledge. MANCOVA results indicated no significant differences between the animated agent conditions, instructional scaffolding strategies or the interactions between the two factors on items associated with manipulated screens when controlling for prior knowledge on knowledge. Similar results were found for comprehension. No significant main effects were found for instructional scaffolding strategies or the interaction between the two animated agent conditions and instructional scaffolding strategies.

The present study also examined the interaction between field dependent and field independent learners, animated agent conditions and instructional scaffolding strategies. A significant interaction was found between the animated agent conditions and field dependence/independence on knowledge. However, no significant main effects were found on animated agent conditions, field dependence/independence, or instructional scaffolding strategies.

In addition, a significant interaction was found between the animated agent conditions and field dependence/independence on comprehension. The interaction showed when the animated agent was absent; field dependent learners scored significantly higher scores than field independent learners. Second, when the animated agent was absent field dependent learners scored significantly higher than when the animated agent was present. The results for this study are summarized in Table 4.29.

Table 4.29
*Summary of the Study*
**Hypothesis** | **Analysis results**
---|---
**Prior knowledge & individual difference**
Ho1: Prior knowledge will not significantly predict knowledge and comprehension
| Manipulated screens | The correlations between prior knowledge and knowledge and comprehension were significant. |
| Non-manipulated screens | The correlations between prior knowledge and knowledge and comprehension were significant. |
Ho2: Field dependence/independence will not significantly predict knowledge and comprehension
| Manipulated screens | No significant correlation between field dependence/independence and knowledge or comprehension (terminology and comprehension tests) was found. |
| Non-manipulated screens | No significant correlation between field dependence/independence and knowledge or comprehension was found. |
**Effects of the instructional scaffolding strategies on knowledge and comprehension.**
Ho3: There will be no statistically significant differences between instructional scaffolding strategies on knowledge and comprehension
| Manipulated screens | No significant differences were found for instructional scaffolding strategies on knowledge or comprehension. |
| Non-manipulated screens | No significant differences were found for instructional scaffolding strategies on knowledge or comprehension. |
**Effects of the animated agent conditions on knowledge and comprehension**
Ho4: There will be no statistically significant differences between animated agent conditions on knowledge and comprehension.
| Manipulated screens | No significant differences were found for animated agent conditions on knowledge or comprehension. |
| Non-manipulated screens | No significant differences were found for animated agent conditions on knowledge or comprehension. |
**Interaction between animated agent conditions and instructional scaffolding strategies on knowledge and comprehension**
Ho5: There will be no statistically significant interaction between animated agent conditions and instructional scaffolding strategies on knowledge and comprehension.
| Manipulated screens | No significant interaction was found between animated agent conditions and instructional scaffolding strategies on knowledge or comprehension. |
| Non-manipulated screens | No significant interaction was found between animated agent conditions and instructional scaffolding strategies on knowledge or comprehension. |
**Interaction between field dependent learners and field independent learners animated agent conditions, and instructional scaffolding strategies on knowledge and comprehension**
Ho6: There will be no statistically significant interaction between field dependent learners and field independent learners on animated agent conditions and
instructional scaffolding strategies on knowledge and comprehension.

<table>
<thead>
<tr>
<th>Knowledge</th>
<th>A significant interaction was found between field dependent learners and field independent learners on animated agent conditions on knowledge. The interaction showed that field dependent learners performed higher than field independent learners when the animated agent was absent. Alternatively, field independent learners performed better than field dependent learners when the animated agent was present.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension</td>
<td>Significant interaction was found between field dependent learners and field independent learners on animated agent conditions on comprehension. The interaction showed when the animated agent was absent, field dependent learners scored significantly higher than field independent learners. Second, when the animated agent was absent field dependent learners scored significantly higher than the animated agent was present.</td>
</tr>
</tbody>
</table>
Chapter 5

Discussion and Conclusion

The purpose of this study was to examine the effects of an animated agent that provides instructional scaffolding strategies via story mnemonic or cuing question with feedback versus instructional scaffolding strategies alone on student achievement of different educational objectives in multimedia learning. Specifically, the study investigated the effects of two animated agent conditions (with an animated agent, without an animated agent) with two instructional scaffolding strategies (story mnemonic and cuing questions with feedback) on knowledge and comprehension when controlling prior knowledge and field dependence/ independence in multimedia learning.

Discussions of Research Questions

1. Do prior knowledge, and field independence/dependence and predict knowledge and comprehension?

The empirical result showed that prior knowledge significantly predicted knowledge and comprehension. This result is consistent with existing research results (Matthews, 1982; Chiang & Dunkel, 1992). Existing studies indicated that prior knowledge enhances one’s ability to construct representations through assimilation and interpretation. From an information processing perspective, with successful activation of prior knowledge, learners can connect new knowledge to their own existing schema which strengthened understanding.

Alternatively, field dependence/independence did not significantly predict knowledge or comprehension. Field dependence/independence is one of the indicators of
cognitive functioning indicating how individuals perceive information and structure knowledge. Witkin and his colleagues (1962) stated field dependence/independence did not directly measure comprehension or verbal ability. Other researchers suggested that investigating field dependence/ independence with other relevant cognitive constructs such as motivation and self efficacy would produce more meaningful results in terms of learning performance (Bandura, 1997; Saracho, 2001).

2. Is there a main effect of animated agent conditions on knowledge and comprehension when controlling prior knowledge?

No significant main effect of an animated agent was found for knowledge and comprehension when controlling for prior knowledge. To elaborate, participants scored similarly on both the terminology and comprehension tests with an animated agent or without the animated agent. Existing research suggested having an animated agent may play an affective role in learning; but this effect may not extend to learning performance (Moreno, et al., 2001; Rieber, 1990). Several explanations can be made. First, the result may be explained by split attention effect (Sweller, 1988). To elaborate, learner attention may have been split between watching the moving animated agent and focusing on the content. Mayer (2005) asserted that multiple representations of the text, pictures and the animated agent may challenge learners in deciding what to focus on. The novelty of the animated agent may have attracted more attention thereby interfering with learners’ thinking about the question or key words (Harp & Mayer, 1998).

Second, another explanation may due to a lack of opportunities to have a true social experience with the animated agent. Existing studies suggested the interaction between the animated agent and learners are critical for impacting students’ perception (Baylor,
Although the animated agent provided key words and feedback to learners, learners did not have the chance to respond back to the animated agent. Without having strong affective connections between learners and the animated agent from a social cognitive perspective, the effect of the animated agent might not have been reached (Lester et al, 1997).

Last, the animated agent in this study was a cartoon-like character rather than an instructor-like character. The image may have inhibited learning and making an emotional connection or establishing itself as credible as the instructor (Maes, 1997). In turn, learners may have not perceived the agent as an instructor and thus were not motivated to learn the content (Baylor, 2002).

3. Is there a main effect on instructional scaffolding strategies on knowledge and comprehension when controlling prior knowledge?

No significant main effect of instructional scaffolding strategies was found for knowledge or comprehension. It may be suggested that neither instructional scaffolding strategies were beneficial to higher order understanding. Scores on knowledge and comprehension for both story mnemonic and cuing question instructional scaffolding strategies were equally low. The finding may due to the kind of information provided about the keywords or in the cuing questions being detailed rather than comprehensive. In order to facilitate concept acquisition, it may be beneficial to emphasize a comprehensive view of the content to assist the learner in constructing a coherent representation. For example, presenting the story mnemonic strategy required learners to focus on key words rather than on solid synthesis of the content. Alternatively, the same situation applied to cuing question with feedback. The feedback on the cuing question also focused on
detailed information on the unit. As a consequence, effects of instructional scaffolding strategies may not have provided learning guidance as expected.

Another possible explanation of the poor performance may have been due to insufficient use of the instructional scaffolding strategies by learners. Both the story mnemonic and cuing question with feedback required learners to process additional information in order to organize and integrate information on the screens. The story mnemonic strategy asked learners to create the story, which requires learners to elaborate on the associative words. Alternatively, the cuing question with feedback strategy provided learners an opportunity to review the information rather than memorize it. However, key words explanations and feedback only appeared if learners clicked on the lower part of the screen, therefore, seeing it was under the control of the learner. It is unknown whether or how often learners actually clicked on the “Show Me” button to display the definition of the keywords or get a cuing question. Without sufficient effort and time to engage in using the instructional scaffolding strategies, the benefits of instructional scaffolding strategies may have been limited. In addition, the results may suggest that both instructional scaffolding strategies were not used enough to allow them to search for information in the long-term memory to connect the screen information to existing knowledge.

4. Is there a significant interaction between animated agent conditions and instructional scaffolding strategies on knowledge and comprehension when controlling for prior knowledge?
No significant interaction was found for knowledge or comprehension. The explanation may due, as described previously, to split attention or an overload of working memory (Kalyuga, Chandler & Sweller, 2003).

5. Is there a significant interaction between field dependence/independence on animated agent conditions and instructional scaffolding strategies on knowledge and comprehension?

Based on the empirical results, a significant interaction was found between the animated agent conditions and field dependence/independence. Specifically, field dependent learners had significantly higher scores than field independent learners when the animated agent was absent. In addition, the results showed field dependent learners performed better when the animated agent was absent than when the animated agent was present.

The explanation may be due to the animated agent not being perceived as a social entity as expected or support field dependent learners to focus the important concepts. In addition, the diagram may have already aided for field dependent learners to understand the instruction. Therefore, the effects of the animated agent were minimal for field dependent learners.

Conclusion

This study examined the effects of an animated agent that provides scaffolding with story mnemonic or cuing question with feedback instructional scaffolding strategies on
student achievement of different educational objectives in multimedia learning. The findings provided several insights into multimedia designs. First, prior knowledge was a significant predictor of knowledge and comprehension because prior knowledge provides the framework for assimilating new information into existing knowledge. Second, no significant prediction was found between field dependence/independence and knowledge or comprehension. This may due to the fact that field dependence/independence is related to individual perceptions of information processing, rather than having an effect in learning performance. Thus, considering other relevant variables with field dependence/independence would be more meaningful in predicting academic performance.

Third, no significant main effect was found between animated agent conditions. Split attention effect and cognitive load may be the critical factors in explaining the results. As a consequence, the extra information and practice did not provide pedagogical support as expected.

Fourth, two instructional scaffolding strategies were found to be equally ineffective. The results suggested that providing detailed information rather than comprehensive information through the instructional scaffolding strategies may have focused attention on the wrong type of learning, or the learners did not actually choose to see the scaffolds.

Lastly, a significant interaction was found between field dependence/independence and animated agent conditions. That is, field dependent learners had higher scores than field independent learners when the animated agent was absent. The explanation may due to the fact that the animated agent was distracting field dependent learners attention.
The study provided the opportunity for the researcher to explore educationally designed interventions to understand the effects of the animated agent by bridging theories and practical designs. By examining the effects of the animated agent through different research phases, the study produced meaningful insights for the field regarding the use of the animated agent with instructional scaffolds.

Practical Implications

Based on empirical results from the main and design based assessment studies, several implications can be drawn.

1. Prior knowledge is an important indicator in learning because it can influence how learners select, organize, and assimilate new information into existing knowledge. It is important to take it into account and activate prior knowledge at the beginning of the lesson when designing instruction in multimedia environment.

2. Field dependence/independence is a cognitive style that affects processing information and perception. Messick (1994) suggested that field dependence/independence measures learning style rather than learning ability in terms of structuring information. Thus, it is understandable that field dependence/independence was not a significant predictor of knowledge and comprehension in this study.

3. The presence of the animated agent did not improve performance in this study. The empirical evidence suggests that embedding an animated agent may not be a promising feature in the multimedia environment, and specifically not for
complex content. The basic assumption about using advanced pedagogical features is aimed at supporting learning and building connections between information and prior knowledge rather than inhibited learning. But this did not happen in this study. Mayer (2005) suggested providing metacognitive strategies to accommodate working memory capacity rather than embedding novel or distracting details that inhibit learning. Thus, reconsidering the use of the animated agent in the multimedia environment is suggested.

4. Instructional scaffolding strategies were aimed at providing pedagogical supports to enhance learning. However, the lack of a main effect on instructional scaffolding strategies may suggest that using other instructional strategies that stimulate reflective thinking and link ideas with prior knowledge can be considered for complex content. Pressley at al. (1987) suggested using self generated elaboration rather than providing elaboration to may be more effective for learners because the connection in the elaboration is more congruent with learners’ knowledge structure. Specifically, this involves activating prior knowledge by using familiar information that connects to new information (Pressley, Snyder, Symons, & Cariglia, 1989). Although this was the intent of using cuing questions and story mnemonic, both were equally ineffective in promoting knowledge and comprehension.

5. The present study showed that field dependent learners performed better when the animated agent was absent. This may imply that the function of the animated agent was not perceived to be a social entity as expected and did not help focus details for field dependent learners. Without fully articulating the
function of the animated agent as a teaching assistant, field dependent learners may not benefit from the pedagogical supports that stem from the animated agent. Therefore, instructional designers need to reconsider pedagogical supports for field dependent learners when designing an animated agent.

6. Two implications can be drawn from the design based assessment study. First, the verbal prompt that the animated agent provided was not effective because it were redundant information for learners. Second, the visual prompts that the animated agent provided were effective for facilitate learning because it served as the salient cue and help learners to understand the main concept in an efficient way. Therefore, when designing instructional strategies, instructional designers need to balance levels of information that instructional strategies should provide.

**Recommendations for Future Study**

Several recommendations for future study are indicated as follows.

1. The present study attempted to understand the effects of an animated agent that provides instructional strategy support. It is suggested that future studies provide learners with an option at the beginning of the study to choose whether they want to have the animated agent present or not. The purpose of the option is to give learners control over the pedagogical supports and the presence of the animated agent as they need them rather than having them present all of the time. Providing this option may support learners without being distracting, thereby increasing their motivation for learning.
2. Future studies should focus on pedagogical design features of the animated agent that would strengthen the connection to the content. That is, research involving the animated agent should focus on how to exhibit the animated agent’s pedagogical ability when learners interact with the content (Mayer, 2003). In addition, future studies should consider maximizing pedagogical supports of the animated agent by designing an animated agent that teaches the content with a human voice. It is assumed that using the animated agent to teach the content would be more effective than on-screen narration in a multimedia environment because of cognitive capacity for processing information (Atkinson, 2002). Specifically, the animated agent can use a teaching aid to articulate scientific concepts. By combining the animated agent behaviors with various pedagogical strategies, learning outcomes may be improved.

3. This study should also be replicated with a different population. It is recommended that high school students without well-developed learning strategies be involved.

4. Future studies should add control groups that presented on screen text and diagrams only in order to compare with other treatment groups to gain a further understanding of the effects of the animated agent.

**Limitations of the Study**

The study must be interpreted with caution based on four limitations.
1. It is important to note that the animated agent was designed based on the specific content in the multimedia environment. Specifically, the design was aimed at facilitating conceptual knowledge rather than problem-solving skills or critical thinking. It was assumed that the effects found in this study for the animated agent and instructional scaffolding strategies would vary across domains and types of performance being measured.

2. The majority of the participants in this study were freshmen at a public university in the eastern U.S. Results should be generalized with caution. It is assumed that different populations would lead to different conclusions.

3. The present study did not measure other relevant variables that may have affected the effect of the animated agent, such as motivation or cognitive load. By adding these variables, the study would have had more systematic results.

4. Due to the desire to understand the effects of the animated agent, only the test items that corresponded with instructional interventions were used for the analysis. Thus, the low reliability of terminology and comprehension tests should be considered when interpreting the results.

5. Participants in this study were mainly from an engineering department. Their prior knowledge of the biology domain was relatively low. Thus, it is expected that they may have had limited interests in context about the human heart.

**Summary**
The study provided interesting insights in terms of the effects of an animated agent on knowledge and comprehension. Although no effect was found for the animated agent when studied alone, an interaction effect was found when field dependence/independence was introduced. Through discussion of each research question, practical implications and recommendations were provided for future study. It is hoped that results from this study will inform the field providing additional empirical data to understand the role of the animated agent in multimedia learning and stimulate future research for more practical and effective designs.

References


Appendix A

Prior Knowledge Test

Directions: Select the answer you feel best completes the sentence.

Question 1. The part of the tooth which contains the hardest substance in the body is the:
   a. root
   b. dentine
   c. cement
   d. enamel

Question 2. The digestion of food occurs principally in the:
   a. stomach
   b. small intestine
   c. mouth
   d. large intestine

Question 3. Contraction of the smooth muscle of the alimentary canal is called:
   a. peristalsis
   b. digestion
   c. absorption
   d. assimilation
Question 4. Worn-out red blood cells are decomposed in the:
  a. heart
  b. lungs
  c. kidneys
  d. liver

Question 5. “Swollen glands” means an enlargement of the:
  a. lymph nodes
  b. heart valves
  c. vena cava
  d. protal vein

Question 6. The chief value of perspiration is that it
  a. eliminates body odors
  b. opens the pores
  c. reduces weight
  d. regulates body temperature

Question 7. Endocrine glands produce:
  a. chyme
  b. endoplasm
  c. hormones
  d. serums

Question 8. The body is stimulated to unusual activity by increased secretion from the:
  a. pancreas
  b. adrenal glands
  c. thyroid gland
  d. thymus gland

Question 9. The spinal cord is made up of:
  a. bone tissue
  b. cartilage tissue
  c. connective tissue
  d. nerve tissue

Question 10. Nerves from the eyes and ears are connected to the:
  a. cerebellum
  b. cerebrum
  c. medulla
  d. spinal cord
Question 11. The chromosome number of the body cells of identical human twins is:
   a. 12
   b. 24
   c. 46
   d. 92

Question 12. The person who can give blood to any other person but can receive only his own type blood has blood type:
   a. A
   b. O
   c. AB
   d. B

Question 13. The ribs are attached to the spine and meet in front of the body at the:
   a. skull
   b. limbs
   c. joints
   d. breastbone

Question 14. The ribs protect the:
   a. stomach
   b. breastbone
   c. spinal Cordially
   d. lungs

Question 15. The hollow interior of the long bones is filled with:
   a. marrow
   b. minerals
   c. red and white corpuscles
   d. haverson canals

Question 16. The windpipe is located -----the esophagus:
   a. in front of
   b. behind
   c. to the left of
   d. to the right of

Question 17. The carbon dioxide-oxygen exchange with the atmosphere occurs in the:
   a. nose
   b. trachea
   c. lungs
   d. bronchi
Question 18. Blood is oxygenated in the capillaries of:
   a. air sacs
   b. heart
   c. muscle
   d. liver

Question 19. During inspiration, the ribs:
   a. do not move
   b. move downward
   c. move inward
   d. move upward

Question 20. The part of the brain that controls respiration is the:
   a. medulla
   b. cerebellum
   c. cerebrum
   d. spinal cord

Question 21. A defense of the body against bacteria is:
   a. hemoglobin
   b. phagocytes
   c. red blood cells
   d. blood platelets

Question 22. The disease hemophilia is associated with
   a. the bone structure
   b. blood clotting
   c. the structure of nervous tissue
   d. the formation of red corpuscles

Question 23. The liquid that bathes every cell and acts as a medium of exchange is:
   a. cell sap
   b. fibrinogen
   c. lymph
   d. fibrin

Question 24. Urine is stored in an organ called the:
   a. diaphragm
   b. kidney
   c. bladder
   d. lungs
Question 25. Secretions of the ductless glands pass:
   a. into tubes or ducts
   b. directly into the blood
   c. directly into the organs where they are used
   d. out of the body

Question 26. Inactivity of the thyroid gland from infancy may produce a condition known as:
   a. diabetes
   b. beriberi
   c. cretinism
   d. Addison’s disease

Question 27. The concentration of sodium and potassium in the blood is controlled by:
   a. adrenin
   b. cortin
   c. insulin
   d. secretin

Question 28. Diabetes is caused by the improper functioning of the:
   a. parathyroids
   b. thyroids
   c. pancreas
   d. adrenals

Question 29. The adult human heart is said to beat approximately---times per minute.
   a. 85
   b. 72
   c. 60
   d. 58

Question 30. Growth and repair of boy tissue involves:
   a. protein
   b. fats
   c. starch
   d. sugar

Question 31. Blood enters the heart through:
   a. arteries
   b. vena cavas
   c. the aortic arch
   d. pulmonary veins
Question 32. Blood leaves the heart through the:
   a. tricuspid valve
   b. aorta
   c. superior vena cava
   d. mitral valve

Question 33. The portion of the heart which divides longitudinally into 2 halves is called the:
   a. myocardium
   b. tendons
   c. pericardium
   d. septum

Question 34. A blood vessel which carries deoxygenated blood is the:
   a. aorta
   b. pulmonary artery
   c. hepatic artery
   d. pulmonary vein

Question 35. The backward flow of blood in the veins is prevented by
   a. muscles
   b. valves
   c. the heart beat
   d. the lymphatics

Question 36. The chamber of the heart which pumps oxygenated blood to all the parts of the body is the:
   a. left auricle
   b. right ventricle
   c. right auricle
   d. left ventricle
Appendix B

Terminology Test

Directions: Select the answer you feel best completes the sentence and mark the corresponding circle.

1. _____ is(are) the thickest walled chamber(s) of the heart.
   A. Auricles
   B. Myocardium
   C. Ventricles
   D. Pericardium
   E. Endocardium

2. The contraction of the heart occurs during the _____ phase.
   A. Systolic
   B. Sympathetic
   C. Diastolic
   D. Parasympathetic
   E. Sympatric

3. Lowest blood pressure in the arteries occurs during the _____ phase.
   A. Sympatric
   B. Sympathetic
   C. Diastolic
   D. Systolic
   E. Parasympathetic

4. Blood from the right ventricle goes to the lungs through the _____.
   A. Tricuspid Valve
   B. Aortic Artery
   C. Pulmonary Artery
   D. Pulmonary Veins
   E. Superior Vena Cava

5. The _____ is(are) the strongest section(s) of the heart.
   A. Left Ventricle
   B. Aorta
   C. Septum
   D. Right Ventricle
   E. Tendons

6. When blood returns to the heart from the lungs, it enters the _____.
   A. Left Auricle
   B. Pulmonary Valve
C. Left Ventricle
D. Right Ventricle
E. Pulmonary Artery

7. Vessels that allow the blood to flow from the heart are called the _____.
   A. Veins
   B. Arteries
   C. Apex
   D. Tendons
   E. Valves

8. Blood passes from the left ventricle out the aortic valve to the _____.
   A. Lungs
   B. Body
   C. Aorta
   D. Pulmonary Artery
   E. Left Auricle

9. The chamber of the heart which pumps oxygenated blood to all parts of the body is the _____.
   A. Right Auricle
   B. Left Auricle
   C. Aorta
   D. Left Ventricle
   E. Right Ventricle

10. The _____ is another name for the part of the heart called the heart muscle.
    A. Apex
    B. Epicardium
    C. Endocardium
    D. Myocardium
    E. Septum

11. _____ is(are) the part(s) of the heart which controls its contraction and relaxation.
    A. Myocardium
    B. Endocardium
    C. Ventricles
    D. Auricles
    E. Septum

12. The _____ is the name given to the inside lining of the heart wall.
    A. Epicardium
    B. Endocardium
    C. Pericardium
13. Blood from the body enters the heart through the ______.
A. Aortic Artery
B. Pulmonary Veins
C. Pulmonary Artery
D. Superior and Inferior Vena Cava
E. Superior Vena Cava Only,

14. The membrane which borders the inside lining of the pericardium and is connected to the heart muscle is called the ______.
A. Extoxim
B. Epicardium
C. Endocardium
D. Myocardium
E. Ectocardium

15. The ______ allow(s) blood to travel in one direction only.
A. Septum
B. Valves
C. Arteries
D. Veins
E. Tendons

16. The ______ is the common opening between the right auricle and the right ventricle.
A. Mitral Valve
B. Tricuspid Valve
C. Septic Valve
D. Pulmonary Valve
E. Aortic Valve

17. The ______ is the triangular flapped valve between the left auricle and the left ventricle.
A. Aortic Valve
B. Pulmonary Valve
C. Septic Valve
D. Tricuspid Valve
E. Mitral Valve

18. The semi-lunar valves are located at the entrance to the ______.
A. Pulmonary Veins
B. Superior and Inferior Vena Cava
C. Pulmonary and Aortic Arteries
D. Mitral and Tricuspid Valves
E. ventricles

19. The outside covering of the heart is called the ______.
A. Endocardium
B. Epicardium
C. Pericardium
D. Myocardium
E. None of These

20. Immediately before entering the aorta, blood must pass through the ______.
A. Left Ventricle
B. Mitral Valve
C. Lungs
D. Superior Vena Cava
E. Aortic Valve
Appendix C

Comprehension Test

Directions: Select the answer you feel best answers the question and mark the corresponding circle. When finished with

21. Which valve is most like the tricuspid in function?
A. Pulmonary
B. Aortic
C. Mitral
D. Superior Vena Cava

22. When blood is being forced out the right ventricle, in which position is the tricuspid valve?
A. Beginning to open
B. Beginning to close
C. Open
D. Closed

23. When the blood is being forced out the aorta, it is also being forced out of the.
A. Pulmonary Veins
B. Pulmonary Arteries
C. Superior Vena Cava
D. Cardiac Artery

24. The contraction impulse in the heart starts in
A. The Right Auricle
B. Both ventricles simultaneously
C. Both Auricles Simultaneously
D. The Arteries

25. In the diastolic phase the ventricles are
A. Contracting, full of blood
B. Contracting, partially full of blood
C. Relaxing, full of blood
D. Relaxing, partially full of blood

26. During the first contraction of the systolic phase, in what position will the mitral valve be?
A. Begging to open
B. Open
C. Beginning to close  
D. Closed

27. During the second contraction of the systolic phase, blood is being forced away from the heart through the  
A. Pulmonary and Aortic Arteries  
B. Superior and Inferior Vena Cava  
C. Tricuspid and Mitral Valves  
D. Pulmonary Veins

28. When blood is entering through the vena cava, it is also entering through the  
A. Mitral Valve  
B. Pulmonary Veins  
C. Pulmonary Artery  
D. Aorta

29. When the heart contracts, the  
A. Auricles & Ventricles contract simultaneously  
B. Ventricles contract first, then the auricles  
C. Right side contracts first, then the left side  
D. Auricles contract first, then the ventricles

30. While blood from the body is entering the superior vena cava, blood from the body is also entering through the  
A. Pulmonary Veins  
B. Aorta  
C. Inferior Vena Cava  
D. Pulmonary Artery

31. When the blood leaves the heart through the pulmonary artery, it is also simultaneously leaving the heart through the  
A. Tricuspid Valve  
B. Pulmonary veins  
C. Aorta  
D. Pulmonary Valve

32. When the pressure in the right ventricle is superior to that in the pulmonary artery, in what position is the tricuspid valve?  
A. Closed  
B. Open
C. Beginning to Close
D. Confining pressure from the right auricle

33. When the ventricles contract, blood is forced out the
A. Superior and Inferior Vena Cavas
B. Pulmonary veins
C. Tricuspid and Mitral Valves
D. Pulmonary and Aortic Valves

34. Blood leaving the heart through the aorta had left the heart previously through the
A. Vena cava
B. Pulmonary veins
C. Pulmonary artery
D. Tricuspid and Mitral Valves

35. When the blood in the aorta is exerting a superior pressure on the aortic valve, what is the position of the mitral valve?
A. Closed
B. Open
C. Beginning to open
D. Confining pressure from the right ventricle

36. When the tricuspid and mitral valves are forced shut, in what position is the pulmonary valve?
A. Closed
B. Beginning to open
C. Open
D. Beginning to close

37. During the second contraction of the systolic phase, in what position is the aortic valve?
A. Fully open
B. Partially open
C. Partially closed
D. Fully closed

38. Blood is being forced out the auricles simultaneously as blood is
A. Entering only the vena cava
B. Being forced out the pulmonary and aortic valves
C. Passing through the tricuspid & mitral valves
D. Being forced out through the pulmonary artery

39. If the aortic valve is completely open, the
A. Second contraction of the systolic phase is occurring
B. Diastolic phase is occurring
C. Tricuspid & mitral valves are completely open
D. Blood is rushing into the right & left ventricles

40. When the heart relaxes, the
A. Auricles relax first, then the ventricles
B. Right side relaxes first, then the left side
C. Left side relaxes first, then the right side
D. Ventricles relax first, then the auricles
Appendix D

Informed Consent Form for Social Science Research

The Pennsylvania State University

Title of Project: Effects of Animated Agent with Instructional Strategies in Facilitating Student Achievement of Different Educational Objectives in Multimedia Learning

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Purpose of the Study: The purpose of this research study is to examine how the animated agent who provided instructional strategies supporting students for learning the human heart content

Procedures to be followed: You will take a prior knowledge test and Group Embedded Figure Test, and then study a web-based instruction about the human heart, its parts, and functions. After completing the study, you will be asked to take two criterion tests.

Duration: It will take approximately one-hour to complete the entire experiment.

Risks/Discomforts: There are no risks or discomforts related to this research that would be beyond normal daily living.

Benefits: By taking and Group Embedded Figure Test, you will be able to understand your learning style.

Compensation for Participation: Participants will receive extra points for EGEE102 course. There is another option to participating to receive the extra points. This option is to practice the review exercise of the unit. Please see the course instructor for additional information about alternatives to the research. The due date for the equitable alternative to the research is due by December 17, 2007.
Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

Statement of Confidentiality: Your participation in this research is confidential. Only the person in charge, and his/her assistants, will know your identity. The data will be stored and secured in a password protected file. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared. The following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Department of Health and Human Services, Penn State University’s Social Science Institutional Review Board, and Penn State University’s Office for Research Protections.

Rights to Ask Questions: You can ask questions about this research. Contact with Hsin I Yung, hcy103@psu.edu questions. You can also call this number if you have concerns about this research, or if you feel that you have been harmed by this study. If you have questions about your rights as a research participant, or you have concerns or general questions about the research, contact Penn State University’s Office for Research Protections at (814) 865-1775.

You must be 18 years of age or older to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this form for your records.

______________________________________________ _____________________
Participant Signature                                                                Date

The informed consenting procedure has been followed.

______________________________________________ _____________________
Person Obtaining Consent                                                                Date
Appendix E

Directions for Animated Agent with Story Mnemonic Group

Directions

After reading each unit, clicking on the “Key word” button, the keyword of the unit will be presented. Once the word is presented, it is important to click on the word. The explanation of the word will be provided. For example, in computer screen four, after reading the unit, click on the “key word” button(Figure1), the word “myocardium” will be presented(Figure 2). And click on the word “myocardium”, the animated agent will provide the explanation of the word (Figure 3).

Figure 1

Figure 2
Figure 3

Unit 3: The Heart's Structure

The heart contains several layers of muscle and muscle. The first set of
muscles outside the heart is a thin muscle called the pericardium. It is composed of
a tough, transparent elastic tissue. It protects the heart and prevents the
muscle from tearing. The innermost layer of the heart muscles is called the
myocardium. It is attached to the heart's interior.

The heart muscle is called the myocardium, which controls the contraction and
relaxation of the heart. The myocardium is made up of the heart's muscles
responsible for the pumping of the blood. The muscle varies in thickness; for example, the muscle in
the atria walls is thicker than in the ventricle walls. Finally, the endocardium is the innermost
lining inside of the heart wall.
Appendix F

Direction for Story Mnemonic Group

Directions

After reading each unit, clicking on the “Key word” button, the keyword of the unit will be presented. Once the word is presented, it is important to click on the word. The explanation of the word will be provided. For example, in computer screen four, after reading the unit, click on the “key word” button (Figure 1), the word “myocardium” will be presented (Figure 2). And click on the word “myocardium”, the explanation of the word will be provided (Figure 3).
Unit 3: The Heart's Structure

The heart consists of several layers of muscle and muscle. The first set of muscle is the heart in a thin double-walled sac. The layer which forms the outer wall of the sac is called the pericardium. It is composed of a tough, transparent elastic tissue. To protect the heart from friction against the walls of the heart. The inner part of the double-walled sac is called the epicardium, it is attached to the heart's muscle.

The heart muscle is called the myocardium, it controls the contraction and relaxation of the heart. The myocardium contracts by filling the greater volume of the heart and its contraction is responsible for the propulsion of the blood through the body. The muscle tissue is thickened, for example, the muscle in the wall of the heart compared to the thickness of the muscle in the ventricle wall. Finally, the endocardium is the inner lining of the chambers lining inside of the heart wall.
Appendix G

Direction for Animated Agent with Cuing Question with Feedback Group

Directions
After reading each unit, click on the “show me” button (Figure 1), the animated agent will present the practice question (Figure 2). Once clicking on one of the answers, the animated agent will provide the feedback for you (Figure 3).

Figure 1

Figure 2
The heart is divided into an upper chamber and a lower chamber. The upper chambers on each side of the apex are called atria; the lower chambers are called ventricles. Atria have thick walls and act as receiving vessels for the blood, while the ventricles have thinner walls and act as pumping organs of the blood away from the heart. Although there is no direct communication between the right and left sides, both sides function interdependently.
Appendix H

Directions for Cuing Question with Feedback Group

Directions

After reading each unit, click on the “show me” button (Figure 1), the practice question will be presented (Figure 2). Once clicking on one of the answers, the feedback will be generated (Figure 3).
Figure 3
Appendix I

Story Mnemonic Sample

Sample 1

Blood was racing through the veins in a marathon, each cell trying to cause the function of blood pressure first. Mary was in running the marathon and fell to the ground, unable to breathe or feel her heart beat. The blood cells dashed furiously through the veins until they reached the myocardium layer of the heart, which was protecting the forlorn organ at this time in Mary’s fate. Through the Superior vena cava, the blood poked through the tube into the heart, each trying desperately to make it in time. Auricle pressure on the heart opened up the doors of the valves. They were in the right ventricle and saw the tricuspid valve. Some of the older cells went through and held the flap for all the other cells to go through. A younger cell who had lost her parents in the dash looked back when the flap was shut and tried to force her way back, but could not re-open the valve. A wiser old cell picked her up and moved her along, as a tear flicked down her face.

They found their way to the mitral valve, where they entered the left ventricle, the strongest part of the heart. The little cherub felt herself grow powerless in the contraction. They moved through to the pulmonary valve, which led them to the pulmonary artery and they were shipped off to the lungs. On her way through the tube, the little cell saw her parents running down the aorta, and she knew they had an important job to do. She would meet them again – but not yet. At this very moment, she had given Mary a breath, and she was partly responsible for why they were all still alive.
Sample 2

Jenny takes a tour of the heart. She starts at the apex, which is the southern-most part of the heart, the part that you can feel beating. While being bumped around, she spots an auricle. The auricle is filled with blood and Jenny can see this, because the walls are so thin. They are also very far from her, because they reside in the upper portion of the heart. Jenny leans back, tired from all the jolting around and rests on the myocardium, which is the heart muscle. This is the part that controls the contractions and the relaxations of the heart. Next, Jenny dives into the superior ven cava, which is the part that deposits blood into the auricles and all body parts above the heart. The tricuspid valve is the part that allows the blood to go through.

After a quick lunch break, Jenny continues onto the pulmonary artery, which is where the blood is carried away from the heart, so that it can become clean. The mitral valve allows the flow of blood from the left auricle to the left ventricle, which happens to be Jenny’s favorite part so far. The aorta is where the gift shop is held. It is also the largest artery that carries the blood away from the heart. The pulmonary valves guard the right ventricle, which is a sight to Jenny’s eyes. The auricle pressure even bothers Jenny, but it also opens the tricuspid valve. By the time the second contraction has occurred, Jenny has had enough and she is done touring the heart.
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