

**UNDERSTANDING THE EFFECTS OF DIFFERENT STUDY METHODS ON
RETENTION OF INFORMATION AND TRANSFER OF LEARNING**

by

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**A thesis submitted to the Faculty of Education
in conformity with the requirements for
the degree of Master of Education**

Queen's University

Kingston, Ontario, Canada

December, 2007

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ABSTRACT

This study investigates the effect of elaborate retrieval, which is a byproduct of spaced practice, on adult cognition. It was hypothesized that elaborate re-conceptualization of new information, within a context that was disparate from the one used during learning, could facilitate learning transfer through the development of a broader conceptual frame of reference. The re-conceptualization task was not expected to degrade rote definitional memory. The two re-conceptualization tasks used in this study were termed model-building and free study. The model building task required the development of a personalized conceptual model using information provided within three spaced narrated information passages. The free study task required the unaided study of all three passages.

Transfer of learning and rote memory were evaluated using a general knowledge test and a knowledge extension test. These tests were given at the end of the experiment. The general knowledge test required participants to match concept labels and definitions which were provided during the experiment. The knowledge extension test required participants to transfer knowledge amassed during the experiment to a complex “real world” situation. The results demonstrated that learners, who completed the spaced re-conceptualization task, improved their ability to transfer new information as the spacing intervals lengthened. Participants who were required to study the same information without any instruction did not show learning transfer improvement. Both groups illustrated parallel improvements in rote memorization due to spacing.

ACKNOWLEDGEMENTS

It is with sincerity that I would like to thank my supervisor, mentor, role model, and friend Dr. Denise Stockley. It is only on a rare occasion that a person reflects the true nature of a situation with such intense optimism. It is this ability, which Denise carries with natural ease, that has helped me find what I hope will become my life's work. Without her willingness to always be available, share her extensive knowledge base, and be patient regardless of the mistakes I have made, my time at Queen's could not have been nearly as enjoyable or productive.

I would also like to thank my committee members Drs. Nancy Hutchinson and Don Klinger. Nancy is always willing to share her knowledge, smile, and insight on all aspects of my graduate experience. She has always taken the time to mentor, guide, and reassure me regardless of the intense responsibilities required of someone in her position. The honesty and academic rigour, in which Dr. Don Klinger has approached my work, has been instrumental in developing my abilities as a researcher. In the complex world of statistics, Don has always been willing and able to provide a guiding light.

Without the help of those who generously donated their time, this thesis would not have been possible. In particular I would like to thank my mother in law, Bala Murthy, for all her help and hard work.

Lastly, without my family I would not be here. Whether it has required fighting with elementary school teachers to put me into the advanced stream in high school, or supporting me during the completion of my Master's program, my Mom and Dad have always supported me. Your belief in me was contagious, and without it, I may have never believed in myself. Sujji, without your unbending support of my academic dreams,

they may have become just that. Thank you for your willingness to suffer the ‘starving student’ life in the pursuit of my dreams. Tosh and family, whether it was the door that is never closed at ‘hotel Rusholme’, or the footsteps you left in front of me, you have been instrumental in guiding me along my path.

DEDICATION

I dedicate this thesis to Sujji, my wife and support system.

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CHAPTER 1

Introduction

Learning researchers have for many decades asked whether it is more effective for learners to study steadily in one session (often called massed study) or to study over a number of sessions with time between the sessions (referred to as spaced study) (see review by Dempster, 1989). Similarly, researchers have long investigated whether testing should be conducted immediately after a learning session (referred to as massed testing) or after a time delay (referred to as spaced testing) (Cull, 2000; Glover, 1989). In essence, the discussions center around one overlying question: is spaced practice (i.e., the combination of spaced study and spaced testing) more effective than massed practice (i.e., the combination of massed study and massed testing) for learners' abilities to retain newly learned information? The answer, supported by a vast majority of research into spaced practice, is a quantifiable 'yes' (see meta-analyses by Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006; Janiszewski, Hayden, & Sawyer, 2003).

The robust effect of spaced practice has since led researchers to vary the lengths of spaced practice intervals and retention intervals, the types of study materials used, and the amount of support or scaffolding given during the learning exercise (e.g., Carpenter & DeLosh, 2006; Cepeda et al., 2006; Cull, 2000; Glover, 1989). However, the majority of spaced practice studies have asked participants to study or take a test of materials that are identical or very similar to the materials originally presented (Cepeda et al.). In the current study, participants in the experimental group were asked to study the originally presented materials in a new context. To be successful, participants were required to re-

conceptualize the information by determining how it might apply within a new, personally relevant context. Since the recovery of information within a new context was conducted at increasingly longer spaced intervals, it was referred to as spaced re-conceptualization throughout this study.

For spaced re-conceptualization to be used effectively in this study, it was important to find participants who, on the whole, tended to be self-motivated and able to view new information as being applicable within multiple contexts. If this was not the case, it was possible that participants may not have been able (or motivated) to effectively use spaced re-conceptualization. Since (according to adult learning theorists) a key attribute of adult learning is the propensity to use self-motivated and creative problem solving, adult participants were used (e.g., Demetriou, 2003; Knowles, 1977; Yan & Arlin, 1995). Self-motivation is referred to as the propensity to use intrinsic motivation from internal sources, instead of extrinsic motivation from external sources (see Ryan & Deci, 2000). In support of the concept of the self-motivated adult learner, Ross-Gordon (2003) states that “[t]he andragogical model presumes that although adults will respond to external motivators such as a job promotion, the most potent motivators are internal” (p. 44). For the adult learner to solve problems effectively using self-motivation, potential solutions contained in long-term memory must be scanned and evaluated (e.g., Perry & Winne, 2006; Piaget, 1977). Howes (2007) explains that “LTM [Long-term memory] is widely defined as content that can be retained for longer than about 45 seconds. The upper boundary of LTM is permanent retention” (p. 104).

One difficulty with problem solving in this manner is the inability to identify cross contextual knowledge (Piaget, 1977; Rumelhart, 1980). In other words, it tends to

be more difficult to identify information in memory when it has been encoded in a context that is disparate from the context of the problem (Gick & Holyoak, 1983). However, if this obstacle can be surmounted, similar information can be transferred from one context to another. Salomon and Perkins (1989) labeled the process of knowledge transfer between contexts as “learning transfer.” They submitted that learning transfer can occur through two different processes, termed high-road and low-road transfer. High-road transfer requires the learner to coordinate cross contextual information using active mental effort and concentration. Low-road transfer is the product of contextual or circumstantial cues that trigger processes that have been automatized through multiple repetitions (e.g., an English speaking person who uses the same phonetic rules to read all languages written in Roman characters). Spaced practice is one popular method for promoting concentration and memory retention, and will be used in this study to support the learning transfer process.

Rationale

The goal of this study was to develop and test tasks that use spaced practice to facilitate the learning transfer process. Spaced practice is expected to improve memory retention using two mechanisms; elaborate retrieval and variable encoding. The first mechanism, termed elaborate retrieval, refers to the effortful retrieval of information from long-term memory stores (Carpenter & DeLosh, 2006). Researchers have found that using time lapses between learning intervals, especially if disparate information is presented, causes knowledge in long-term memory to degrade. As a result, learners are required to increase the allocation of mental effort and concentration to retrieve degraded information (Carpenter & DeLosh, 2006; Cull, 2000; Glover, 1989). Traditionally, mental effort and attention through spaced practice have been hailed for

their ability to improve the retention of rote memory (Cepeda, et al., 2006; Glover, 1989). In the current study, it is theorized that elaborate retrieval can be used to facilitate both improved rote information retention and high-road learning transfer.

A second common explanation given for the effectiveness of spaced practice is termed variable encoding (e.g., Appleton-Knapp, Bjork, & Wickens, 2005; Bjork & Allen, 1970; Dempster, 1989). Variable encoding is based on findings that new concepts are strongly associated with the context in which they are encoded (Tulving & Thomson, 1973). Spaced practice by definition provides multiple encodings of information in (at least moderately) different contexts. Researchers have theorized that contextually diverse encoding provides more contextual routes or paths to the concept (Appleton-Knapp, et al., 2005). It was expected that conceptual diversity, due to variable encoding, would make solutions more attainable in problem solving situations. In the current study, it was predicted that variable encoding would facilitate low-road learning transfer. Although low-road learning transfer is not traditionally associated with conceptual transfer, in this study, it was expected to augment the use of elaborate retrieval (Mayer & Greeno, 1972).

The overall goal of this study is to examine how spaced re-conceptualization affects information retention and learning transfer. It was hypothesized that improved information retention and learning transfer would be facilitated by elaborate retrieval and variable encoding. Through these processes the concepts learnt in this study were predicted to become more malleable. As a result, model-building participants were expected to be able to more efficiently apply newly learnt concepts to new and dissimilar contexts than participants studying in a more traditional way.

Purpose

The intention of this study was to design a learning task to improve learning transfer. The two study tasks that were tested are termed model-building and free study. Using spaced practice, the model-building task gave participants the opportunity to elaborately re-conceptualize information and subsequently apply it to a new context. In contrast, the free study task did not scaffold the re-conceptualization process, and participants were required to self-direct their study strategies. It was expected that the model-building task would give participants better access to conceptual information and would increase the number of low-road transfer triggers. The experimental methodology was identical for both groups with the exception of the study task used.

Prior to the model-building task, participants were required to identify a new and personally relevant context for the application of key concepts. Boxes containing concepts, arrows, brackets, and input text boxes were actively moved around the screen to build a model explaining the conceptual fit within the new pre-identified personal context. In contrast, free study participants were only instructed to thoroughly study the narration script and the conceptual definitions for a future test.

To better understand the effects of spaced practice, the time intervals between the presentation of information and the free study and model-building tasks were incrementally lengthened. The interval lengths were approximately the same for both groups. Using this technique, the effect of interval length on learning transfer could be compared both across learning tasks and spacing intervals. As there was no spacing interval between the first passage and the first study opportunity, the first passage was used as a spacing control across both groups. Thus improvements in learning retention

or transfer, after the first study opportunity, could be related to the spacing interval provided.

By comparing the results of the knowledge transfer and general knowledge tests given at the end of the experiment, differences between the model-building and free study groups were examined. The intent of the general knowledge test was to evaluate the participants' rote memory of definitional terms. In contrast, the knowledge extension test was designed to evaluate the participants' abilities to transfer knowledge amassed during the experiment to a complex "real world" situation. Both the free study and model-building tasks required participants to study 12 key concepts, presented in three separate information passages (see Appendix A).

The specific hypotheses tested within this study were:

- 1) Participants in the model-building group will score higher than participants in the free study group on both the knowledge extension scenario and the multiple-choice test of general knowledge.
- 2) Due to spaced practice, participants will achieve increasingly higher scores on the general knowledge test of information provided in the three passages.
- 3) Due to spaced practice, participants will achieve increasingly higher scores on the knowledge extension test of information provided in the three passages.
- 4) Participants in the model-building group will rate satisfaction with the learning process higher than free study participants in terms of usefulness, interest, and applicability.

Definitions

Automatized Learning – The creation of new schema through the slow and repetitive automatization of multiple schematic structures.

Constructive Abstraction – Developing new schemas through the coordination of the co-functional components of existing schemas.

Elaborate Retrieval – The use of concentrated effort to retrieve information from long-term memory.

Infralogical Abstraction – The use of low inhibition to abstract key points from a larger body of information.

Intentional Learning – The use of mental effort to create new schema through the deliberate activation of co-functional schemas, or components of schemas.

Logological Abstraction – The most inhibitive reductive abstraction, used to decipher the underlying moral, value, or concept from one or more bodies of information.

Reductive Abstraction – The inhibition of schemas, or components of schemas, which have a distracting or distorting influence on a given task or cognition.

Schema – The arrangement and connection of two or more concepts linked together by (a) common attribute(s) or function(s).

Schematic Accretion – The addition of concepts or terms to schema without structural alteration.

Schematic Tuning – The alteration of schema through assimilation or accommodation to incorporate a new idea or concept.

Spaced practice - The finding that information is better retained if it is studied or tested more than once, with either new learning material or time separating study or test repetitions.

Spaced re-conceptualization – A concept that has been developed for this study, and refers to the retrieval of information from long-term memory, within a new context, after a spaced interval.

Variable Encoding – The theory that information is retrieved from long-term memory using cues which are similar to contextual cues used during encoding.

CHAPTER 2

Literature Review

The intent of the literature reviewed in this chapter is to provide a synthesis of the processes and products of cognition that form the foundation on which the model-building task has been built. The review begins by discussing how schema could be altered by the experimental design in this study. Next the transfer of schema to diverse contexts is explored. Finally, the effect of using spaced practice on a multimedia platform is investigated.

The following review of literature is not intended to be exhaustive. The literature surrounding schema theory focuses primarily on the period between 1960 and 1990. According to McVee, Dunsmore, and Gavelek (2005), it was within this period that seminal research regarding the effects of schema theory on cognition and cognitive processes was conducted. More recent literature has developed a closer focus on literacy and language development and is beyond the scope of this study (Anderson & Pearson, 1991; McVee, Dunsmore, & Gavelek, 2005; Tierney & Shanahan, 1991). Similarly the learning transfer literature referred to in this study focuses on findings of the late 80's and early 90's. The reason for this limitation is that in recent years learning transfer literature has tended to focus on the affective variables influencing learning transfer (i.e., self-efficacy, computer experience, education, motivation, etc.) and, more specifically, learning transfer in a corporate training environment (e.g., Brown, 2001; Chiaburu & Marinova, 2005; Lim & Johnson, 2002). A close examination of these factors is beyond the scope of this thesis.

Schematic Development

Rumelhart and Norman (1978) suggested that learning is the process of encoding information into long-term memory in the form of multiple schemas. Schemas are thought to be co-functional groupings of information arranged and encoded into sense making packages (e.g., Anderson, Spiro, & Anderson, 1978; Rumelhart, 1980; Schnotz, 2005). Schemas tend to be grouped by common attributes that are coordinated to form a unique meaning (e.g., Armbruster, 1986; Pascual-Leone & Irwin, 1994a, b; Salomon & Perkins, 1989). Schematic structures can either be constructed or synthesized by combining co-functional attributes of two or more schemas (constructive abstraction), or through the incorporation of new information into an existing schema (reductive abstraction) (e.g., Pascual-Leone, 1994a, b; Price & Driscoll, 1997; Rumelhart & Norman, 1978).

The first type of schematic development, termed constructive abstraction by Pascual-Leone and Irwin (1994a), was theorized to be accomplished through either (a) the atomization of ‘coordinated’ schemas (automatized learning) or (b) the activation of co-functional schemas via mental energy (intentional learning). Initially, automatized learning is a slow and challenging process. Multiple schemas are coordinated and repeatedly practiced through trial and error, until an automatized and effortless coordination is achieved. Pascual-Leone and Irwin use the example of a person who moves to a new city. Initially, the person may learn the route from home to work, home to the grocery store, etc. Eventually, as these routes are coordinated and intertwined (e.g., learning to go from work to the grocery store), a map of the city (or at least an area of

the city) is conceptualized, so that traveling no longer requires the same concentration of mental energy.

Conversely, intentional learning is achieved by concentrating mental effort on schemas that may be useful in a given situation. Schemas that are perceived to be co-functional are coordinated and are used systematically to achieve a specific goal. An example of intentional learning is a student who is attempting to solve a math problem. Although the student may possess many, and potentially all the schemas required to solve the problem, mental concentration and effort must be used to decide which schemas should be used, and in what order. Initially, this process requires focus and concentration; however, as the process is repeated it becomes more automatized. Eventually, if the problem is solved frequently enough, the once arduous process may itself become an automatized schema (Pascual-Leone, 1994a).

The second type of schematic development, termed reductive abstraction by Pascual-Leone (1994a), is created through inferring information from the outside world. It is evident that the inclusive incorporation of all available external information into long-term memory would be a redundant and impossible task. Thus to cope with vast amounts of information, mental attention focuses only on concepts which are relevant to a particular context (Pascual-Leone, 1994a; Piaget, 1977). Subsequently, schemas not required in the comprehension of context specific information are actively inhibited to help focus attention (Pascual-Leone, 1994a). In this case, inhibition refers to the blocking of schemas that are not related to new information. Depending on the extent of schematic inhibition, concrete or abstract structures can be retained. With moderate inhibition, superfluous information is dismissed and only points that are relevant to the

context are retained. Pascual-Leone and Irwin refer to this type of reductive abstraction as infralogical. A common example of infralogical abstraction is the case of a student who is taking notes in a class. Since it would be impossible for the student to write down every word the professor says, the student abstracts the concepts, words, or ideas that are relevant to the topic, and writes them down.

With increasing inhibition, abstract concepts such as values, morals, or theoretical concepts can be comprehended. This type of reductive abstraction is referred to as logological (Pascual-Leone & Irwin, 1994a). Johnson (1991) gives the example of a lecturer attempting to portray a theoretical idea. If the participants have in-depth knowledge in the area, potentially a definition will suffice. However, if the students are novices, the lecturer may give multiple examples so that the students can abstract the concept from similar or contrasting components within the examples.

Before information that is conceptualized from an external stimulus can be encoded into long-term memory, it must be grouped into a schematic structure. Rumelhart and Norman (1978) and Rumelhart (1980) propose three theoretical procedures for grouping to occur. On the most basic level, new information may be added as a new element of an existing schema. Termed accretion, this process is used in the rote memorization of relatively simple concepts (e.g., phone numbers, word lists, names, etc.). Anderson et al. (1978) represent this idea by describing schemas as having 'slots' and 'placeholders' in which information can be inserted and categorized.

A second, more significant method of coordinating external information into schematic structure is termed tuning (Rumelhart & Norman, 1978). Tuning is a constant process involving the adjustment of current schemas to incorporate new information. Piaget (1977) submits that people tune or adjust their schemas in response to cognitive

disequilibrium. Equilibrium is said to be out of balance when externally received information does not fit within the individual's schematic structure (Piaget, 1977; Wadsworth, 1984). To re-equilibrate, individuals must tune their current schemas to incorporate the new information. However, Piaget also suggests that re-equilibration is fleeting as the human desire to engage information dictates a constant process of increasing equilibration. As a result "[A] system never constitutes an absolute end of a process of equilibration; fresh goals always arise from an attained equilibrium, unstable or even stable; and each result, even if more or less durable, remains pregnant with new progress" (Piaget, 1977, p. 31).

The tuning of a schema to re-establish equilibrium can be accomplished through either assimilation or accommodation (Piaget, 1977; Wadsworth, 1984). Assimilation refers to the manipulation of new information to conform to existing schemas. For example, many people would consider the Apple iPod to be an MP3 player, although multiple functions are unique to this device. In contrast, accommodation refers to the adjustment of a schema to account for externally presented information (e.g., the schema for 'phone' with the introduction of the cellular phone). It is important that assimilation and accommodation are balanced in the adjustment of schema. If only assimilation were to be used, schema would become too broad and language would lose meaning. Alternatively, using only accommodation would create schema that were too specific and even highly related things would be seen as different (Wadsworth, 1984).

The last and most significant method for incorporating external information into long-term memory, as identified by Rumelhart and Norman (1978), is the formation of new schematic structures. The creation of a new structure requires extensive mental time and effort, and may result from the inability to assimilate, or the ineffectiveness of

accommodated schemas. In such a situation the schema can no longer be adjusted to incorporate the new idea, and a new schema must be created. For example, with the introduction of the computer in the 1970's, an individual trying to adjust the schema for 'typewriter' to encompass the concept of a computer may have not been able to reach equilibrium, and therefore a new schema would have had to be created.

The effects of schematic coordination on cognitive processes have been empirically studied by a multitude of researchers (e.g., Anderson, et al., 1978; Price & Driscoll, 1997; Ward, Byrnes & Overton, 1990). To test the effect of schema on rational thought, many researchers have used the four-card selection task developed by Wason (1966) (as referenced by Wason, 1968). Researchers have used this task to present many different constructs in the form of 'if x then y', with 'x' representing the antecedent and 'y' the consequence. In D'Andrade's (as cited in Rumelhart, 1980) experiment, the rule was "if a vowel is on one side, then there is an odd number on the other side." The participants were asked which of the four cards, presented in Figure 1, needed to be flipped over to prove the rule.

The logic required to successfully solve this problem is as follows; if on the back of the 'E' card there is an even number, the rule is disproved, further if on the back of the '8' card there is vowel, then the rule is disproved, therefore these cards must be flipped. However, since the rule does not specify a consequence for cards with consonants or odd numbers, the 'F' and '7' cards do not require checking. In this experiment only 13% of the participants correctly completed the task. Of the participants who were unsuccessful, 70% of the participants erred by flipping over the '7' card. This error has been attributed by researchers as the misinterpretation of the simple conditional

as a bi-conditional. Thus, in addition to the rule that stated “if there is a vowel on one side, then there is an odd number on the other side”, participants extrapolated the rule that “if there is an odd number on one side, then there is a vowel on the other side.” Participants also committed the error of flipping over all cards mentioned by the rule (e.g., Evans, 1980; Rumelhart, 1978).

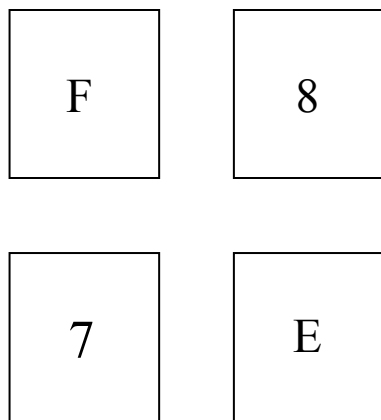


Figure 1. Visual depiction of the four card selection task.

In the second part of D’Andrade’s (as cited in Rumelhart, 1980) experiment, the influence of schema on human cognition was powerfully illustrated. When the context presented by the cards was changed to be more familiar, participants performed much better. In the second experiment participants were asked to imagine that they were store managers at Sears. As managers, they were required to sign the back of any purchase greater than \$30. Four bills were presented; (1) a bill for \$75, (2) the back of a bill without a signature, (3) a bill for \$25, and (4) the back of a bill with a signature. The participants were then asked which cards needed to be flipped over to check for

compliance. Although functionally the same, by changing the paradigm to content that reflects information commonly held in schema, almost 70% of the participants completed the task correctly (D'Andrade, as cited in Rumelhart, 1980). Rumelhart (1980) provides the following explanation for this phenomenon;

The first case is unfamiliar and the subjects have no schemata in which to incorporate the problem and, therefore, can bring only very general problem-solving strategies to bear on the problem. The second case more nearly approximates our "real life" problem-solving situation. Once we can "understand" the situation by encoding it in terms of a relatively rich set of schemata, the conceptual constraints of the schemata can be brought into play and the problem readily solved. (Rumelhart, 1980, p. 57)

It could be argued however, that the information represented in D'Andrade's (as cited in Rumelhart, 1980) first experiment was simply confusing to the participants. As such, they were less careful and simply used all available information in an attempt to prove the rule (e.g., Evans, 1996). A study by Ward, Byrnes, and Overton (1990), also using the four-card selection task, provides further empirical support for D'Andrade's results being due to the entrenchment of schematic models in long-term memory. In this study, concepts from a pilot study that had been demonstrated to be either familiar or unfamiliar to participants were used. The concepts were then incorporated into rules according to commonly held schemas (entailment) or in rules that were contradictory to commonly held schemas (non-entailment). As a result, four categories were created; (a) familiar entailment (e.g., if it is gasoline, then it is flammable) (b) familiar non-entailment (e.g., if it is flammable, then it is gasoline), (c) unfamiliar entailment (e.g., if it is an onyx, then it has a waxy luster), or (d) unfamiliar non-entailment (e.g., if it has a waxy luster, it is an onyx).

If the discrepancy in D'Andrade's (as cited in Rumelhart, 1980) study was due to a lack of comprehension of unfamiliar concepts, it would be expected that rule (c) and (d) would be most frequently answered incorrectly. However, if the discrepancy was due to the absence of representative schemas, then question (b) and (d) would be most frequently answered incorrectly. The results in this case indicated that compliance with the structure of commonly held schemas was more important than the comprehension of the concepts. Whereas 47% of participant answered the question using the familiar entailment rule correctly, only 21% answered correctly when the familiar non-entailment rule was used. When the unfamiliar non-entailment schema rules were used, only 5% of the people answered the questions correctly.

The coordination of new information with our schemas is not the only factor in problem solving. Riddles often use homographs in a context where only one of the word's representative schemas is available. For example, the statement "the two police officers approached the woods knowing that many of the people in the cabin had died" is confusing, and leads the listener to consider multiple reasons for this expectation. However, by changing only one word, (e.g., the two police officers approached the runway knowing that many of the people in the cabin had died), the riddle becomes clear and an explanation is readily available. Anderson et al. (1978) experimented with this logic by asking participants to read passages describing either an experience in a restaurant or in the grocery store. In both passages, the food items described were identical, but had been found in a prior pilot study to be more fitting in a restaurant setting. Anderson et al. found that 70% of the common food items were recalled by participants who had read the restaurant description. In contrast, only 56% of the

common food items were recalled ($p < .01$) by those who had read the “out of context” supermarket description.

Transfer of Learning

Although schemas may become less clear when referenced in a new context, it is not the case that schemas may only be used within the context in which they were encoded. Thankfully, new contexts can be added to existing schemas, or schemas can be altered to fit into multiple contexts (Price & Driscoll, 1997; Salomon & Perkins, 1989). Without this function, exorbitant amounts of time would be wasted recreating a schema each time an activity was attempted. One could imagine the redundancy of learning how to create a knot in a length, every time this skill was required (wrapping presents, tying shoe laces, tying on a bracelet etc.) This type of transfer, labeled as ‘low-road transfer’ by Salomon and Perkins (1989), is relatively simple and, except for initially learning the skill, does not require extensive mental engagement.

The second type of transfer identified by Salomon and Perkins (1989) is termed high-road transfer. In contrast with low-road transfer, information that is transferred between contexts tends to be more abstract. Once a concept or idea is abstracted using intentional learning and logical reductive abstraction, mental attention and effort is used to transfer the theory, concept, or value to a new context. This type of transfer may be slower, and involve more focus and mental effort on the part of the individual (Pascual-Leone & Irwin, 1994a, b; Salomon & Perkins, 1989; Wadsworth, 1984). Salomon and Perkins (1989) describe two types of high-road transfer; forward reaching and backward reaching. Forward reaching transfer is achieved by using a de-

contextualized concept, abstracted in the past, in a similar context in the future (e.g., a child who transfers organizational skills enforced by a teacher to professional life years later). Backward reaching transfer refers to the use of a decontextualized concept as a tool to solve a different problem (e.g., an adult who uses a childhood anger quelling strategy, such as counting backwards from one to ten, in order to refrain from eating fatty foods later in life).

The contrasting effects of high-road and low-road transfer were clearly demonstrated in an experiment by Mayer and Greeno (1972). The goal of this experiment was to instruct students on how to equate binomial probability problems. One of two instructional booklets, with contrasting instructional methods, was given to each group. The first group studied a booklet containing an explanation of terminology, a conceptual description of probability, instruction on solving the problem, and instructions on analyzing the results. The intent of this booklet was to instruct the students on the theoretical basis of binomial probabilities. The second group studied a booklet containing a step-by-step approach to the solving of binomial problems. It was the intent of this booklet to teach the participants the systematic processes required to solve the equation.

After the material had been studied, both groups were given the same transfer test. The test contained four different types of questions; familiar (simple procedural questions), transformed (more complicated procedural questions), unanswerable (illogical process tasks that could not be answered), and questioning (tasks that required an in-depth understanding of the concept of probability). The results indicated that participants in Group 1, who had received the more conceptual instruction, were better

able to understand the concept of probability, and transfer this learning to the unanswerable (63% vs. 43%) and questioning (83% vs. 43%) tasks. In contrast, Group 2 participants were able to solve more systematic and concrete problems. Consistent with the concept of low-road transfer, participants from Group 2 scored higher on both familiar tasks (75% vs. 48%) and transformed tasks (57% vs. 40%). This implied that students who were given step-by-step instructions were able transfer their knowledge to familiar but slightly transformed situations, using low-road processes. However, when students were given a more theoretical knowledge base, they were able to use high-road transfer to find answers for more abstract and relativistic questions.

In Gick and Holyoak's (1983) study, the mechanisms of high-road transfer were more clearly identified. Participants were presented with either one or two stories that were analogous to a target problem. The target problem involved an oncologist who was attempting to perform radiation therapy on a tumour. The oncologist possessed ray guns powerful enough to destroy the tumour, but at full intensity, the ray would also destroy healthy tissue. If the oncologist reduced the intensity of the ray, the tissue would not be destroyed, but neither would the tumour. How then, is the oncologist to save the patient? The correct answer to the question is that the oncologist should point multiple low intensity beams at the tumour so that the intensity when the beams converge is sufficiently intense to destroy the tumour.

When one analogous story which depicted a similar concept, was presented to participants no significant difference in the ability to solve the target problem was found. However, when two analogous stories were presented that depicted a similar concept, participants were better able to abstract the convergence rule and apply it to the

oncology situation. Interestingly, participants were also better able to transfer the embedded concept if a schematic model diagram was created. As a result, two implications for the application of high-road transfer can be drawn from this study. First, the abstraction of theoretical knowledge is facilitated by the use of multiple examples that allow for the underlying message from the sources to be compared and contrasted. Secondly, conceptual modeling may facilitate the recognition and transfer of key concepts to diverse contexts.

These lessons were adapted directly into the current experimental design. First, participants were not only asked to engage with the conceptual information during model-building, but they were also asked to develop a schematic design depicting how the concepts interrelated within a personal context. Participants were also presented with the concepts in multiple but different contexts. This was done to facilitate low-road transfer, and present multiple analogous examples and thus demonstrate the transferability of the concepts. By using elaborate retrieval to perceive and create multiple knowledge transfer opportunities, improved future transfer was expected by the model-building group, on the knowledge extension test, in the current study.

Spaced Practice

The spacing effect, discovered by Ebbinghaus in 1885, has been investigated and shown to be consistent and robust by hundreds of researchers (see meta analysis by Cepeda et al., 2006). Cepeda et al. reported that of 271 spaced practice experiments, only 4.4% failed to achieve meaningful and statistically significant spacing effects. Also, spaced practice has proven to be as flexible as it is robust. Cepeda et al. reported that significant effects of spaced practice have been found in studies with spaced study and

testing opportunities, termed inter-stimulus intervals, ranging from 1 second to 84 days. The time between the last study interval and the test of memory retention, termed the retention interval was found to range from 4 seconds to 2900 days.

Elaborate retrieval and variable encoding have been widely credited for the effectiveness of spaced practice (Cepeda, et al., 2006). Although empirical evidence supports both theories, currently, the theory of elaborate retrieval is most heavily supported in the literature (Bjork & Allen, 1970; Carpenter & DeLosh, 2006; Cuddy & Jacoby, 1982; Glover, 1989; Nagy, Herman & Anderson, 1985). The elaborate retrieval view of spaced practice assumes that if information retrieval is more challenging, it will be remembered for a longer period of time (Carpenter & DeLosh, 2006).

Elaborate Retrieval. According to the elaborate retrieval theory, processes which require more thought, effort, and concentration, should in turn increase the retention of target information stored in long-term memory (Glover, 1989). Glover explored this hypothesis in 1989 by giving 195 first year psychology students 10 minutes to study a 300 word essay about a fictitious city. The students in the experimental group were required to return after two days to take a free recall (no retrieval cues), cued recall (retrieval cues such as the first letter, the start of a sentence, or a picture), or a recognition recall test (the correct answer must be chosen from multiple potential answers).

Glover theorized that fewer retrieval cues, inherent in the free recall of information, would encourage more elaborate recall and thus encourage better long-term memory retention. Therefore, if the free recall formative test group performed better on all tests (free, cued, and recognition), the result could be attributed to elaborate retrieval instead of variable encoding. In contrast, if the participants who had taken a specific

formative test, such as cued recall, performed best on the identical summative test (i.e., cued recall), the results could be attributed to variable encoding. When participants were given the outcome test measure using free recall, cued recall, and recognition recall tests, those participants who had taken the free recall formative test performed best on all test types. As a result, these findings provided support for the elaborate retrieval hypothesis of spaced practice.

A 2006 study by Carpenter and DeLosh further supported Glover's (1989) findings. In this study, 70 first year university participants were each given formative tests on 16, eight-word lists. Participants were divided into three groups; free recall (26), cued recall (23), and recognition recall (21). In the first study, participants in each group were given a study opportunity and a formative free recall, cued recall, and recognition recall test. The results were similar to Glover's finding that regardless of which study or test method was used, free recall intervention words were recalled more accurately. Although Carpenter and DeLosh theorized that the results were due to elaborate retrieval, they conducted a further test to verify the results were not due to the administration of multiple tests.

In the second experiment, the number of recall cues was manually controlled. Words were presented with one, two, three, or four letters to cue a participant's recall of the targeted word. It was hypothesized the provision of fewer cues would enhance the effects of elaborate retrieval, and thus words tested with fewer letter cues would be better recalled. The results of Experiment 2 supported this hypothesis. The percentage of words recalled after being formatively tested using one, two, three, and four cues were

42%, 36%, 35%, and 30% respectively, providing further support for the elaborate retrieval hypothesis of spaced practice.

Spacing and Schematic Development

In the majority of papers reviewed for this thesis, both adults and children have been exposed to spaced practice in a closed environment, using rote memorization tasks that depend on working memory ability (e.g., Bahrck & Hall, 2005; Cull, 2000; Glover, 1989; McDermott, 1996, 2006). Some notable exceptions have used spaced passage reading, union workers participating in spaced training sessions, and air traffic control training (e.g., Fisher & Ford, 1998; Glover, 1989; Hertenstein, 2001; Roediger & Karpicke, 2006). However, the effect spacing has on more complicated tasks, attempting to induce higher-level knowledge abstraction in adults, has yet to be explored. Promising results from Thiede, Anderson, and Therriault (2003) illustrate the potential of spaced practice for the current study. In this study, participants were asked to summarize a reading passage using only five words. The summarizations were done either immediately after reading, after a short delay, or not done at all. Those who had written the words after the delay displayed more apt descriptions and had better retention on a later test than the other two groups. The effectiveness of delayed recall is thought to be due to the decay of misleading and extraneous information from short-term memory (Britton & Gulgoz, 199; Thied, Anderson, & Therriault, 2003). This benefit is amplified if students are able to actively generate or manipulate the data during study as opposed to passively encoding it (Mazzoni & Nelson, 1993).

Multimedia Principles

Many of the tasks used for this study were completed on the computer. The use of this form of technology enabled a more dynamic and fluid interface between the participants, the learning objects, and the experimental content. As such, it is essential that the most recent principles and best practices of multimedia learning be used to inform the study design. The cognitive theory of multimedia learning (CMTL), designed by Mayer (2005), was used as the foundation from which the following study was designed. For example, Mayer recommends that the text should be narrated. The dual channel principle is used to justify narration and is based on the concept that information is transferred through the senses. This implies that information can be processed simultaneously through the visual and auditory channels. Although there is currently disagreement in the literature whether written texts are processed in the visio-spatial sketchpad (the visual component of working memory) or the phonological loop (the auditory component of working memory), researchers seem to agree that simultaneous dual processing of auditory and visual information increases the amount of information that can be concurrently processed (Mayer, 2005; Moreno & Mayer, 2002; Schnotz, 2005). As a result, information that is contextually similar, but not identical, can be presented simultaneously to the benefit of the intended message.

For the dual modality principle to be beneficial some further principles within the CTML must be recognized. First, the contiguity principle states that if two stimuli are presented in one channel (e.g., a labeled model), the two visual images should be presented in close proximity to each other. For example, a model should have labels included within the structure, and not within the notes at the bottom. The second

principle is the coherence principle that states extraneous graphics (e.g., decorative pictures, flashing lights) or words (irrelevant comments, excessively large text) should not be used within the presentation (Mayer, 2005; Moreno & Mayer, 2000). According to arousal theory, extraneous stimuli may be used to stimulate, decorate, or enhance the visual esthetic of a program (Weiner, 1990). However, Mayer rejects this contention because extraneous graphics and words tend only to split the attention of the learner between relevant and irrelevant information. Lastly, the redundancy principle indicates that identical information presented simultaneously in different modalities will not aid learning, and in fact may distract from the overall presentation (Mayer, 2003; Schnotz, 2005).

It was essential that the model-building task used in this study conform to the principles of the CTML. If it did not, poor results on the learning tasks could be attributed to the model-building task, when they were actually a result of the program design. First, the dual channel principle was used extensively within this experiment. All information was delivered by narrated text with only key words appearing in a box at the top of the screen termed the 'toolbox.' The contiguity principle was satisfied as the words from the toolbox were displayed within the model created by the participant. In conforming to the coherence principle, the model components were composed of a single colour and were presented upon a black background. The redundancy principle, which states that identical text and narration should not be presented simultaneously, was not fully complied with in this study. During narration, identical concepts given during narration were displayed via animation in the toolbox. However, since the words were presented subtly, and only one word was displayed from each key point, this process was not expected to negatively influence the study.

Summary

The literature reviewed within this chapter illustrates that through conceptual abstraction, relevant concepts can be synthesized from larger bodies of information (e.g., Gick & Holyoak, 1983; Pascual-Leone & Irwin, 1994a, b). Subsequently, through the processes of accretion and tuning, current schema can be adjusted to incorporate new concepts (Piaget, 1977; Rumelhart & Norman, 1978; Wadsworth, 1984). These concepts were used to inform the spaced model-building and free study tasks highlighted in Chapter 3.

CHAPTER 3

Method

Participants

Thirty participants were recruited in all; 15 participants participated in each of the model-building and free study groups. Participants in this study were comprised of adult learners who were between 23 and 40 years of age. Although age was not recorded before experimentation, the majority of participants were between the ages of 28 and 38. This age range was chosen to engage learners who would likely be more accepting of the multi-contextual applications of conceptual knowledge (Pascual-Leone & Irwin, 1994b).

Similarly, the participant's academic background was not formally recorded. However, all participants had completed high school and at least part of a University or College program. As most research conducted on spaced practice has been completed with first year psychology students, it was expected that this age group would more accurately illustrate the effects of spaced practice on adult learning (Cepeda, et al., 2006). Recruitment was conducted through personal networks of the researcher. Thirteen participants were direct acquaintances of the research, and the remaining 17 were recruited by acquaintances of the researcher. The number of participants was based on guidelines indicating that *t*-tests require between 10 and 30 participants per comparison group (Wilson & Morgan, 2001).

Materials

A program, developed by the researcher, using Adobe Flash was used as the basis for the model-building exercise. The free study group did not use the computer to study, but alternatively used a booklet containing the key terms and the narration script. Both groups used the computer to listen to the narrated passages. Participants from both

groups were given the option to be tested in the institution's computer lab or in a mutually agreed upon location where a laptop computer was made available.

Procedure

Half of the participants were randomly assigned to the model-building group and the other half were assigned to the free study group. Both experimental groups completed a pre-study test of existing domain knowledge on the computer. The domain was cognitive theory. In addition, participants in the model-building group watched a short demonstration of the model-building task. Next, all participants received instructions to listen carefully to the narration as the information would be tested. Each narration was approximately 2.5 minutes. Both experimental groups received the exact same narrated passages, and the same key concepts were displayed on the computer. The only difference between the two groups was the use of the model-building or the free study task. The following process illustrates the steps to completion that participants had to take:

- a. the first narrated information passage was presented to both experimental groups on the computer;
- b. immediately after the first narrated passage the free study experimental group studied the narrated script from the first narrated passage in a booklet, and the model-building group built a conceptual model on the computer of the concepts from the first narrated script;
- c. the second narrated information passage was narrated on the computer to both experimental groups;
- d. the third narrated information passage was narrated on the computer to both experimental groups;

- e. at the end of the third narrated passage the free study experimental group studied the second narrated passage script in a booklet, and the model-building group built a conceptual model on the computer of the concepts from the second narrated script;
- f. all participants took a five minute break;
- g. at the end of the five minute break, the free study experimental group studied the third narrated passage script in a booklet, and the model-building group built a conceptual model on the computer of the concepts from the third narrated script;
- h. both experimental groups completed a 12 question general knowledge test;
- i. both experimental groups completed a knowledge extension test, which was composed of three essay type questions;
- j. lastly, both experimental groups completed a satisfaction questionnaire.

Narrated Information Session

Before each of the three model-building or free study tasks was conducted, all participants were asked to listen to a narrated information session. This session was designed to facilitate inhibition, abstraction, and tuning. The animated placement of the target concepts during narration into a toolbox located at the top of the screen was expected to ensure the concepts could be clearly identified by participants. Moreover, by aiding in the identification of concepts it was expected that participants would be better able to inhibit irrelevant schemas. As the concepts used in this study were complex, multiple examples were used during the narrated session to make them more familiar to the participants. It was expected this would assist in the assimilation or accommodation of new concepts to previously held schemas.

Model-building

Participants completed the model-building exercise with the software program developed for this experiment. Participants used tools such as concept boxes, input text boxes, brackets, and arrows to explain their understanding of the concepts abstracted from the narrated sessions (see Appendix B). Prior to the first model-building exercise, a five minute tutorial was provided to explain and demonstrate the task. Items from the individual's context such as process terms, position descriptors, and product terms, were used to connect concepts from the toolbox in a manner that represented the participant's perspective. For example, if a participant was explaining how the experimental concepts related to driving a car, the participant would be able to connect experimental concepts using phrases such as; put the car in gear, hands on ten and two, turn the radio down, etc. Prior to model construction, participants were required to indicate a personal context in which the model was to be built, in a text box specified at the top of the screen.

Both personal and experimental items were placed within the model using a drag and drop process. All structural components (e.g., squares, arrows, etc) were located at the top of the screen and there was no limit to the number that could be used (see Appendix B). Terms were pre-entered within a box that could not be altered by participants. By placing the mouse pointer over concept definition boxes, the definition for that word appeared. When the mouse pointer was taken away from the word, the definition also disappeared. Participants were given no time limit to complete the modeling task and upon completion of the model, a specified button was pressed, and the next experimental component began. Time spent on each task was not recorded as part of this study.

The model-building process was designed in conjunction with findings from the literature concerning schematic development, spaced learning, and learning transfer. For example, the model-building tasks were staggered to ensure there were progressively longer spaced intervals between each task. This was expected to promote the elaborate retrieval of previously learned concepts. Participants were also required to retrieve previously learned concepts within a context that was specified prior to building the model (see Appendix B). This served two functions; first participants were required to re-conceptualize the information into a context that was different from the one used during the initial narration. This was expected to illustrate to participants the transferability of the concepts, and to promote future transfer. Second, re-conceptualization was conducted within a familiar and self selected environment. Thus participants were expected to have schemas pertinent to the context in which the model was being built. It was expected this would mitigate the difficulties associated with attempting to relate concepts to a context without schematic representation (as was the case with Wason's four-card selection task).

Free study

The free study experimental task allowed participants to study the material in a manner they believed most effective. Highlighters, pencils, pens, erasers, and extra paper were available, although no direct instructions on their use was given. Participants were notified before each study opportunity that they were required to remember the information presented in the narration session for a future test. They were also instructed that no time constraint would be imposed. Participants were asked to study the scripts until they believed the information was thoroughly committed to memory.

Measures

Four assessments were given to every participant in both the model-building and free study groups. The entrance questionnaire was used to control for pre-existing knowledge about human cognition, learning transfer, and spaced practice. The remaining three tests were used to obtain data on the rote memory of conceptual definitions (general knowledge test), the ability to transfer knowledge to new contexts (knowledge extension test), and overall satisfaction with the learning process (satisfaction questionnaire). The specific assessment measures used in this study are described below.

Pre-Study Test (see Appendix C)

A 5 item multiple-choice test was given to assess pre-test knowledge of the cognitive theories of abstraction, schematic development, and spaced practice used in this study. Questions were directly related to the information provided in the study. An independent sample *t*-test and descriptive statistics were used to compare the pre-study test scores of the model-building and free study groups. This was done to ensure that large statistical or mean differences between the scores of the two groups did not decrease the validity of the study.

General Knowledge Test (see Appendix D)

The questions on the general knowledge multiple-choice test required participants to match definitions provided during the study with the corresponding concept. To help control for processing speed, literacy, and/or motivation differences between participants, no time limit was imposed. The general knowledge test contained 12 questions, four from each information passage.

It was expected that using a recognition recall test would be the most appropriate means of measuring rote memory. Experiments by Glover (1989) and Carpenter and DeLosh (2006) illustrated that free recall and cued recall tests required more extensive concentration and effort. As the purpose of the general knowledge test was to investigate the participants' ability to remember which concept label fit with which definition, free recall and cued recall tests were expected to be too rigorous. This was accentuated by the complexity and length of the definitions presented within the experiments.

Knowledge Extension Test (see Appendix E)

The knowledge extension test was adapted from Gick and Holyoak (1983). In this test, Gick and Holyoak used multiple analogous scenarios to investigate the participants' ability to abstract a common theme, and subsequently use it to solve a problem. The cognitive process required to abstract the theme from the scenarios, related directly to the experimental content presented during the narrated passages. The close parallel between the experimental content of the current study, and the cognitive process required for the Gick and Holyoak study, presented an opportunity to use one set of material to test the content from all three narrated passages. It was expected that using only one material source would mitigate the fluctuation in difficulty between the three knowledge extension questions.

Participants were given a dilemma requiring the use of conceptual information provided in all three information passages. They were asked to extrapolate on the information provided, and to explain the effect their decision would have on the parties involved. Test answers were marked by the researcher who was blind to the identity of the participants and their group. Papers were graded in two marking sessions that were spread over two days. Participants were awarded two points for examples of conceptual

transfer from the passage context to the problem context. An additional point was given if the correct conceptual term was used with the implementation of the concept. No point was given for a concept label if it was used incorrectly or without any direct reference to its use. The intent of this marking structure was to identify instances where information had been transferred to a new context, and to not reward definitional reiteration as a result of rote memorization.

To perform well on the first two knowledge extension questions, participants were required to use theories of cognition, presented in the first two narrated sessions, to explain how the main character derived meaning out of two analogous stories. On the third knowledge extension question, participants were required to explain how the main character could use spaced practice to teach his colleagues the lessons learned from the analogous stories. Thus the model-building group participants were required to transfer information twice. Initially, information was transferred from the narrated context to a dissimilar personal context, via the model-building task. Secondly, participants were required to transfer information to answer the knowledge extension questions.

Free study group participants were not scaffolded to ensure the narrated information would be transferred into a different context. Instead, they were given the freedom to study the information in any manner they chose. However, like the model-building group, the free study group participants were required to transfer the information from the narrated passages to the knowledge extension questions. The ability to perform the second transfer was reflected in the test scores for the individual passages.

Answers and models for both groups were completed on the computer to ensure individual participants could not be identified by handwriting. To control for score

inflation due to answer length, participants were given a limit of 250 words, which was controlled via the computer. Evidence in the literature suggests the aforementioned word limit is broad enough to encompass full answers, but short enough to avoid excessive writing (Brown, 2001).

Satisfaction Questionnaire (see Appendix F)

All participants completed an exit questionnaire after completing the extension and general knowledge tests. The questionnaire asked participants to rate the learning process they were involved in based on its interest, usefulness, and applicability. Scores were measured on a 5-point Likert scale. The ratings were used to test Hypothesis 4.

Analyses

Collected data was analyzed with dependent and independent sample *t*-tests, using the Statistical Package for the Social Sciences (SPSS 12.0) program. Although a low alpha was important to ensure that a Type I error would be less likely, the scope of the current study restricted the number of participants that could be included. As such only a moderate level of statistical power was achieved. If the lack of statistical power caused a hypothesis to be incorrectly rejected, a Type II error would be committed. A Type II error may then create an unfair barrier to continued research on spaced re-conceptualization. As such, the middle ground was chosen and a significance alpha of .05 was chosen.

Hypothesis 1

Participants in the model-building group will score higher than participants in the free study group on both the knowledge extension scenario and the multiple-choice test of general knowledge.

General knowledge test scores were calculated for both the model-building and free study groups. Independent sample *t*-tests were conducted between individual passages, and between the final scores, to test for significant learning outcome differences. Second, knowledge extension test scores were calculated for both the model-building and free study groups. Independent sample *t*-tests were conducted between individual passages, and between the final scores, to test for significant learning outcome differences.

Hypothesis 2

Due to spaced practice, participants will achieve increasingly higher scores on the general knowledge test of information provided in the three passages.

With each of the three passages the free study and model-building general knowledge scores were calculated (see Appendix G and H). Three dependent sample *t*-tests were conducted for both groups between passages 1 and 2, 2 and 3, and 1 and 3.

Hypothesis 3

Due to spaced practice, participants will achieve increasingly higher scores on the knowledge extension test of information provided in the three passages

With each of the three passages the free study and model-building knowledge extension scores were calculated (see Appendix G and H). Three dependent sample *t*-tests were conducted for both groups between passages 1 and 2, 2 and 3, and 1 and 3.

Hypothesis 4

Adult participants in the model-building group will rate satisfaction with the learning process higher than free study participants in terms of usefulness, interest, and applicability.

An independent sample t -test was used to compare the ratings in all three categories.

CHAPTER 4

Results

Before any information or instruction was given, all participants completed a pre-study test of domain knowledge. This test was conducted to control for experimental topic expertise. On average, the model-building and free study test scores were below 50%. In total, 5 participants scored higher than 50% on the pre-study test; four participants were in the free study group and one was in the model-building group. Of the participants who achieved passing scores, one received a score of 80% and four received scores of 60% (see Table 1).

Table 1
Distribution of scores between free study and model-building groups

Score (%)	Number of students with specified score	
	Free Study	Model-Building
80	1	0
60	3	1
40	4	6
20	6	7
0	1	0
Average Score	36%	29%

An independent sample *t*-test was conducted to test for differences between the model-building and free study group test scores. The results indicated there was no statistically significant difference between the groups (see Table 2).

Table 2
Independent sample *t*-test between free study and model-
building pre-study test scores

	N	Mean	Standard Deviation	<i>t</i> -statistic	df
Free Study	15	.36	.22	.98	28
Model-Building	15	.29	.15	.98	28

**p* < .05

***p* < .001

Since each question on the pre-study test was associated with one or more of the three passages, each question score was analyzed to determine if existing knowledge may have biased the general knowledge and knowledge extension test results for that passage. The highest scores were found for questions relating to information in passages 1 and 2, with the lowest scores relating to information given in the third passage. With the exception of responses to Question 1 by free study participant, questions using terms held within common vernacular, namely ‘schema’ and ‘tuning’, were answered correctly most often (see Table 3).

Table 3
Correct pre-study responses, question number and target term, and average test score for participants in the free study and model building groups

Target Concept	Target Concept Passage	Number of Correct Responses	
		Free Study	Model Building
1) Logological Abstraction	1	7	1
2) Schema	2	5	10
3) Elaborate Retrieval	3	1	2
4) Tuning	2	8	6
5) Inhibition, Logological abstraction, tuning	1 and 2	6	3

Before the general knowledge and knowledge extension test scores were analyzed, reliability was calculated using Cronbach's alpha on both tests. Generally an alpha score above .70 is considered to be sufficient evidence that scores are reliable (Cronbach, 1950). The reliability scores of both the general knowledge and knowledge extension tests were found to be greater than .70 (see Table 4).

Table 4
Reliability test results for the model-building and free study groups

Test	Cronbach's α
General Knowledge	.72
Knowledge Extension	.87

Although the general knowledge test demonstrated reliability within participants' scores, a ceiling effect was found. On average, general knowledge test scores on all passages were very high for both the free study and model-building groups (see Table 5). As a result of high Passage 3 scores, the third passage model-building and free study standard deviations were very low.

Table 5

Mean and standard deviation of general knowledge and knowledge extension test scores for each passage and as a total of all passage

	<u>General Knowledge Test Scores</u>			<u>Knowledge Extension Test Scores</u>		
	N	Mean Score	Std. Deviation	N	Mean Score	Std. Deviation
Passage 1 – MB	15	3.07	1.10	15	4.60	3.70
Passage 2 - MB	15	3.07	1.22	15	5.27	3.88
Passage 3 - MB	15	3.87	.35	15	7.07	4.08
All Passages - MB		10.27	1.22		16.93	10.44
Passage 1 – FS	15	3.07	1.22	15	5.67	3.70
Passage 2 – FS	15	3.33	1.18	15	4.80	3.63
Passage 3 – FS	15	3.93	.26	15	4.60	4.01
All Passages - FS		10.33	2.13		15.07	9.76

MB – Model-Building

FS – Free Study

This study was designed to investigate four hypotheses. Hypothesis 1 projected that participants in the model-building group would do significantly better than those in the free study group in terms of both the knowledge extension and the general knowledge scores. The descriptive statistics only partially support Hypothesis 1. The free study group's general knowledge scores were equal to, or greater than, the model-building scores on all three passages. Also, the free study group had higher knowledge extension scores on all three passages. In contrast, the model-building group's knowledge extension scores were higher than free study scores for Passages 2 and 3 (see Table 5). To determine the statistical significance of these results, independent samples *t*-tests were completed to determine if significant differences existed between the two groups. There were no statistically significant differences between these two groups on any one passage or on the total of all three passages (see Table 6). Due to these findings, Hypothesis 1 was rejected.

Table 6

Independent sample *t*-test between model-building and free study group passage and cumulative scores (FS-MB)

	<i>t</i> -test Statistic	df	General Knowledge Test Average Difference	<i>t</i> -test Statistic	df	Knowledge Extension Test Average Difference
Passage 1	0.00	28	0	0.74	28	1.07
Passage 2	0.61	28	0.27	-0.34	28	-.47
Passage 3	0.59	28	0.07	-1.67	28	-2.47
Total Score	0.11	28	0.07	-0.51	28	-1.87

FS – Free Study

MB – Model-Building

**p* < .05

Hypothesis 2 predicted that participants within both groups would do significantly better on the general knowledge test as a result of spacing between passages 1, 2, and 3.

The descriptive results partially supported this hypothesis. The mean model-building general knowledge test scores increased between passages 2 and 3, and 1 and 3. However, no difference was found between the mean scores from passage 1 and 2. Similarly, the free study general knowledge scores increased between passages 1 and 2, 1 and 3, and 2 and 3 (see Table 5). To statistically verify these results, dependent sample *t*-tests were conducted between passages 1 and 2, 2 and 3, and 1 and 3 for all general knowledge scores. The results partially supported this projection. Both the model-building and free study groups showed statistically significant increases between the first and third passages (see Table 2). Further, a significant increase was found between the second and third passages, within the model-building group (see Table 7).

Table 7

Paired sample *t*-test between general knowledge and knowledge extension passage scores

	<i>t</i> -test Statistic	df	General Knowledge Test Average Difference	<i>t</i> -test Statistic	df	Knowledge Extension Test Average Difference
Passage 1 and 2 – MB	0.00	28	.00	-0.71	28	.67
Passage 2 and 3 - MB	-3.06	28	.80*	-3.07	28	1.80**
Passage 1 and 3 - MB	-2.57	28	.80**	-3.30	28	2.47**
Passage 1 and 2 – FS	-1.00	28	.27	0.80	28	-.87
Passage 2 and 3 – FS	-2.58	28	.60	1.16	28	-.20
Passage 1 and 3 – FS	-1.87	28	.27*	0.20	28	-1.07

MB – Model-Building

FS – Free Study

p* < .05*p* < .01

Hypothesis 3 projected that participants within both groups would do significantly better on the knowledge extension test as a result of spacing between passages 1, 2, and 3. This hypothesis was only partially supported by the descriptive statistics. Interestingly, the free study knowledge extension scores decreased between passages 1 and 2, 2 and 3, and 1 and 3. In contrast, the model-building knowledge extension scores increased between passages 1 and 2, 2 and 3, and 1 and 3 (see Table 5). On average, the model-building group's knowledge transfer scores increased by 35% between the first and third passages (see Table 5). To test these results statistically, a paired sample *t*-test was performed on passages 1 and 2, 2 and 3, and 1 and 3 for both the free study and model-building groups. The model-building group showed a significant score increase between the first and third, and the second and third passages (see Table 7). The free study group

showed no statistically significant score change between any of the passages for the knowledge extension test (see Table 7). As a result, Hypothesis 3 was partially supported.

Lastly, Hypothesis 4 projected that participants in the model-building group would have a better overall perception of the learning process. To test this hypothesis, all participants were presented with three questions inquiring about the usefulness, interest, and applicability of the material presented during the learning process. This questionnaire was given directly after the knowledge extension test. Participants selected their answer from a 5-point Likert scale, ranging from strongly disagree to strongly agree (see Appendix F). Although the mean rating scores of interest and applicability by model-building participants were slightly higher, the difference was small (see Table 8). Further, there was no difference found between the mean ratings of usefulness between the two groups. An independent sample *t*-test was conducted between the rating scores of the model-building and free study groups to confirm the findings of the descriptive statistics. There was no statistical difference between the rating scores of the two groups (see Table 8).

Table 8
Means, standard deviations, and *t*-test statistics of model-building and free study rating scores

	FS Mean Score	FS Standard Deviation	MB Mean Score	MB Standard Deviation	<i>t</i> -test Statistic	df	Average Difference
Usefulness	4.1	.88	4.1	.61	-0.02	28	0.01
Interest	3.9	.80	4	.68	-0.24	28	-0.07
Applicability	3.7	.70	4	.39	-1.25	28	-0.27

MB – Model-Building

FS – Free Study

**p* < .05

***p* < .01

The results indicate partial support for Hypotheses 2 and 3. However, Hypotheses 1 and 4 were rejected. Although free study participants scored higher than model-building participants on the general knowledge test, and model-building participants scored higher than free study participants on the knowledge extension test, there were no statistically significant differences between the two groups. As a result, Hypothesis 1 was rejected. Hypothesis 2 was supported between Passages 1 and 3 for both groups, and between Passages 2 and 3 for the model-building group. Between these passages both groups showed a statistically significant mean general knowledge score increase.

Hypothesis 3 was supported by the model-building group, but not by the free study group. The model-building group showed significant knowledge extension score increases between Passages 1 and 3, and 2 and 3. In contrast, although not statistically significant, the free study group showed decreasing mean knowledge extension scores between Passages 1 and 2, 2 and 3, and 1 and 3. Finally, Hypothesis 4 was rejected outright, as both groups rated the learning process almost identically in terms of usefulness, interest, and applicability. Further, there was no statistical difference between the groups on any of the three variables.

CHAPTER 5

Discussion

The intent of this study was to investigate the effects of spaced model-building and free study tasks on learning transfer. A secondary interest was to investigate the effect of the model-building and free study programs on rote definitional memory, using the general knowledge test. Lastly, this study analyzed the effects of the model-building and free study learning processes on the participants' evaluation of the usefulness, interest, and applicability of the information presented during the study.

Pre-Study Test

The results of the pre-study test indicated that participants did not have substantial knowledge of the cognitive theories presented in the narrated passages. Although some questions were answered correctly by more than half of the participants in the free study or the model-building group, no concept yielded a 50% or greater correct response rate from both groups. This indicates that correct answers were somewhat random, and may not indicate extended knowledge of a particular concept.

Although 24 of the 30 participants scored 40% or lower and 14 participants had a score of 20% or lower, four participants achieved a score of 60% and one participant scored 80%. There is a danger that these participants may have skewed the data. Further, four of the five participants, including the one that scored 80%, were within one group. However, since these participants were in the free study group, pre-existing knowledge of the experimental theories was expected to skew the data against the projected hypotheses. Thus any results found to support the hypotheses would be strengthened by the bias

discovered within the pre-study test. As a result, all 30 participants' general knowledge and knowledge extension scores were analyzed.

Learning Transfer

Although previous research (i.e., Badrick & Hall, 2005; Cepeda, et al., 2006; Dempster, 1989) has shown that rote memorization of simple pieces of information is significantly improved by spaced practice, there are few practical indications that spaced practice is used in the classroom (Dempster, 1989). In the current spaced practice study, instead of simply 'remembering' pieces of information, model-building participants were also required to adapt, schematically organize, and integrate complex and newly presented concepts into their own personal context. It was expected that these participants would take a more multi-contextual approach to learning. In contrast, previous research suggests that free study participants may have tended to rely primarily on simple rote memorization techniques when their encoding technique was not scaffolded (Bahrick & Hall, 2005).

Since no significant difference was found between the model-building and free study groups for Hypothesis 1, a discussion of the difference between general knowledge and knowledge extension test score means cannot be validated. Low participant numbers may have resulted in insufficient statistical power, and as a result, statistically insignificant findings. As a result, a lack of true differences, or a test that is not sensitive enough. However, due to the results of Hypothesis 3 it can be said with statistical confidence that in this study, the spaced re-conceptualization of concepts using model-building improved participants' abilities to transfer learning to a new context. In contrast, there is no evidence that similar spacing intervals were effective in the free study group.

Moreover, there was a non-significant trend towards decreasing knowledge extension test scores as the time between the narrated passages increased in the free study group. If the logic presented in the literature follows, declining free study results could be due to students relying more heavily on rote memorization, and, as a result, having more difficulty applying the information when given a new situation.

The findings from the knowledge extension test given in this study indicate that spacing can be used effectively in complex learning situations. Spaced re-conceptualization was able to facilitate the transfer of newly learned complex concepts into a real world scenario. Moreover, scaffolded learning transfer had no adverse effects on the ability of participants to memorize the conceptual definitions. This was illustrated by findings that there were no significant score differences on the multiple-choice test between participants in the two groups. Unlike much of the spaced practice literature, this finding may have a direct implication for educators. If subsequent research supports the use of spaced re-conceptualization in true academic environments, with diverse age groupings, educators may have the opportunity to use spacing as a technique to encourage students to be aware that similar concepts can be applied in multiple different contexts.

On the surface this technique may seem difficult to implement in a classroom environment. After all, information within a class or unit does not necessarily have conceptually transferable components. However, the model of multi-contextual instruction does not demand that the concepts be new or, for that matter, contained within the same unit or class. Many concepts taught within the context of a specific topic or subject are already known to the student in a different context (Pascual-Leone & Irwin,

1994a; Salomon & Perkins, 1986). If the findings in this study are trustworthy, they suggest that, by using elaboration to apply similar concepts to diverse contexts during study, future learning transfer can be scaffolded. Further, the results indicate that if parallels are continuously pointed out between concepts presented in different contexts, the concept itself can become malleable and more easily identified by students attempting to solve problems in future situations.

Elaborate retrieval has been shown to be effectively facilitated through spaced practice. By implementing spaced re-conceptualization into classroom curricula, it may be possible to increase students' engagement and interest in instructional material. To implement spaced practice instructors need only to split instruction into two sections that are interceded by a disparate topic. This technique would serve two purposes; first students would not need to concentrate on one topic for an extended period of time, and second the beneficial effects of elaborate retrieval and variable encoding could be realized.

Rote Memory

The results of Hypotheses 2 and 3 support the theory that spaced model-building facilitates learning transfer without significantly disrupting a student's ability to remember definitional information. The results of Hypothesis 2 provide support for findings in the literature that spaced free study improves a student's ability to retain and reproduce concepts and their definitions (e.g., Cepeda, et al., 2006). However, this study also provides evidence that the model-building program does not significantly detract from the student's ability to memorize definitional information. Therefore, results from this study are inconsistent with findings in the literature, which indicate that more

relativistic instructional styles tend to decrease a student's ability to remember rote information (e.g., Badrick & Hall, 2005, Gagner & White, 1978; Mayer, 1975).

Participants' Perceptions

So far, all the findings have been based on the assumption that the spaced practice tasks in this study effectively scaffolded elaborate retrieval. However, for elaborate retrieval to be effective, the participant must actively re-engage with re-presented information, and be motivated to recover memory that has been eroded by spacing. As a result, negative attitudes regarding either free study or model-building activities could have skewed the data. Participants were questioned regarding the perceived interest, usefulness, and applicability of the learning process. As no statistical differences were found between the groups, it appears the results from both groups were unaffected by individual perceptions. In general, both groups indicated they agreed that the learning process was interesting, useful, and applicable. Although not statistically significant, model-building participants also showed a trend towards a higher rating for the applicability of the learning process. Thus, although Hypothesis 4 was rejected, it is doubtful that personal perceptions from either group, or the participants as a whole, affected the data.

Conclusion

Spaced practice was used in the current study to facilitate the learning transfer process. Dempster (1988) describes the spacing effect as “one of the most dependable and replicable phenomena in experimental psychology” (p. 627). It is clear that regardless of the use of varying settings, interval lengths, participants, and learning materials spaced

practice is a robust and viable phenomenon (see meta-analysis by Cepeda, et al., 2006). Elaborate retrieval and variable encoding have been credited for the robust and consistent effects of spaced practice (e.g., Bjork & Allen, 1970; Carpenter & DeLosh, 2006; Cuddy & Jacoby, 1982; Dempster, 1989). In this study elaborate retrieval was exploited in an attempt to aid learning transfer.

The first step in using spaced practice to promote learning transfer was to attempt to facilitate the participants' ability to abstract the most important concepts from the narrated passages. Pascual-Leone and Irwin (1994a) suggest that abstraction requires the inhibition of schemas in memory that are not associated with the required concepts. To assist in this process target concepts were placed into a toolbox during the narrated session through computer animation. The next step was to ensure that the information was adapted into schema contained in long-term memory. According to the cognitive literature regarding schematic construction, these new concepts would need to be tuned through either assimilation or accommodation (Piaget, 1977; Rumelhart, 1980).

A third consideration in the design of the model-building exercise was to permit participants to identify a personal context on which to build the model. It is essential that each participant was able to identify with the context in which transfer would occur. D'Andrade (as cited in Rumelhart, 1980) found that learning transfer occurs more effectively in contexts for which individuals have a schematic representation. Similarly, Anderson, Spiro, and Anderson (1978) found that memory retention and recall was improved when a list of foods was presented in a contextually appropriate manner.

The results of this study suggest students' perspectives can be broadened and information can be better applied to diverse contexts by using the systematic facilitation

of learning transfer, through conscious interjection of spaced practice and re-conceptualization. Further, although not researched in the current study, it is conceivable that students, who are challenged to look for multiple contextual applications in their classroom setting, will also be able to translate these techniques into a more productive personal study technique. If the basic concept can be abstracted from its contextual cover, it may become easier for students to accept and draw parallels between new ideas. Also, if parallels are drawn between the conceptual bases of information, the stress of learning ‘new things’ in every class can probably be reduced.

The result of introducing conceptual transfer into the curriculum would be a ‘tying’ together of conceptual similarities. Through the increased proficiency of learning transfer, and a pedagogic shift towards the development of conceptual transfer, a more imaginative and less redundant culture of instruction could be nourished. Such a culture could help promote the creation of connections between conceptual information in memory. It is through these connections that truly innovative thinking and new ideas can take root.

Future Research

This study takes a step towards illustrating that adapting pedagogic techniques to incorporate spaced re-conceptualization, can positively impact learning transfer in adults. Further research will be needed to investigate the effect of spaced re-conceptualization on diverse age groups in diverse subject areas. Although adults tend to take a more relativistic view of new information, and tend to demonstrate more acceptance of its multiple applications, it is unclear if the common true/false perception of new information common in adolescence would present a barrier to the application of space

re-conceptualization (Demetriou, 2003; Knowles, 1977; Pascual-Leone & Irwin, 1994b; Yan & Arlin, 1995). A second important question that was not answered in this study regards the long-term impact of spaced re-conceptualization on self-regulation during study. Spaced re-conceptualization will be a much less effective technique if it only applies to the subject which is currently being taught. However, if high-road learning transfer is adopted as a general self-regulation technique due to the consistent re-conceptualization within a classroom setting, the benefits may be realized systematically throughout the student's life.

Limitations

A key limitation in the current study was the number of participants. Thus it is conceivable that some of the noticeable trends in the data were not found to be significant due to a lack of statistical power. A second limitation in this study is the complexity of both the experimental content and constructs. The model-building task was difficult to perform, and required the patient manipulation of multiple learning tools. In some cases, it is possible that the effort required to master the model-building task, may have interfered with the participants' abilities to encode the presented information. This could partially explain the lack of significant improvement between the first and second narration sessions. Thirdly, the complexity of the experimental content may have caused participants to doubt their ability to use and manipulate the newly presented concepts. As a result, negative self-efficacy may have played a role in lowering the results of the knowledge extension test.

Overall, the findings in this study support the use of spaced re-conceptualization to scaffold learning transfer. Although future research is needed to determine the extent to

which this concept can facilitate learning in real world situations, this study takes an important first step to establishing viability for the concept of spaced re-conceptualization. It is fitting that the shared conceptual properties of spaced practice, learning transfer, and schematic development have been coordinated to establish a technique that may help learners coordinate key elements such as these in the future.

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Appendix A

Information Passages

Passage 1

Topic - Abstraction

Key Terms –inhibition, infralogical, logological, abstraction

This section will discuss the removal of important concepts from large bodies of information, this process is called abstraction. To abstract information, people inhibit information receptors in their brain that do not deal with the concepts they are interested in. For example, if a person would like to understand the moral of a story, they will inhibit all components of the brain that do not deal with cause and effect relationships.

If a greater number of information receptors are inhibited, a person will tend to understand the big picture. This is termed logological abstraction. In this way morals and values are understood from stories and movies. However, if less extensive inhibition takes place, more concrete conceptual information can be understood. This is termed infralogical abstraction. For example, rules and directions can be retrieved with less extensive inhibition. Infralogical and logological process can work together. An example of this would be watching a movie, you may initially retain all parts of the movie that are of interest to you through infralogical processing. However, later when somebody asks what the movie was about, you will take each of the instances and use logological process to abstract a more general description of the movie.

This is the end of session 1.

Passage 2

Topic - Schematic Development

Key Terms –tuning, assimilation, accommodation, disequilibrium

In this session we will discuss how a schema is created. A schema is composed of concepts that are grouped together due to shared properties. For example, we all have a schema for the concept of a dog, depending on your feelings about dogs these schema may be positive (i.e., beautiful, fun loving, friendly), or negative (i.e., scary, dirty, noisy).

The changing of a schema is called tuning. Tuning usually occurs when we observe something in the outside world that contradicts our schema. When this occurs we experience cognitive disequilibrium. For example, if you have a negative schema about dogs, but then get a dog and learn to love it, you may experience cognitive disequilibrium. In this case you may need to tune your schema.

Tuning can be accomplished with assimilation or accommodation. Assimilation occurs when you change the new concept to fit the schema. In our current example, you would still have negative feelings about dogs, however you may consider your dog special and unlike other dogs. However, if you use accommodation to fit your schema, you will adjust the schema to fit the concept. In our current example, you may change your schema for dog to a more positive conceptualization.

This is the end of session 2.

Passage 3

Topic - Spaced practice

Key Terms – elaborate retrieval, variable encoding, Inter Stimulus Interval, retention interval

In this session we will discuss spaced practice. In general if a concept is taught twice, it can be remembered for a longer period of time if it isn't presented in direct succession. This finding that retention can be improved by allowing time to pass between the presentations of identical concepts, is called spaced practice. The time between teaching two identical concepts is termed the inter-stimulus interval. And the net amount of time the concept can be remembered or retained is called the retention interval.

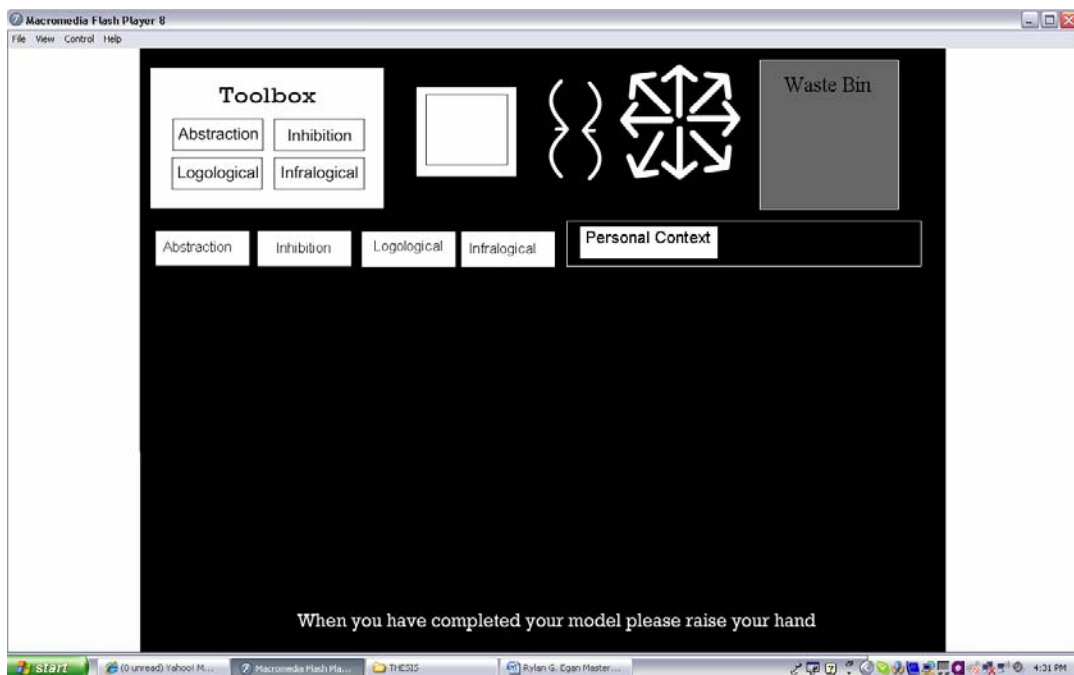
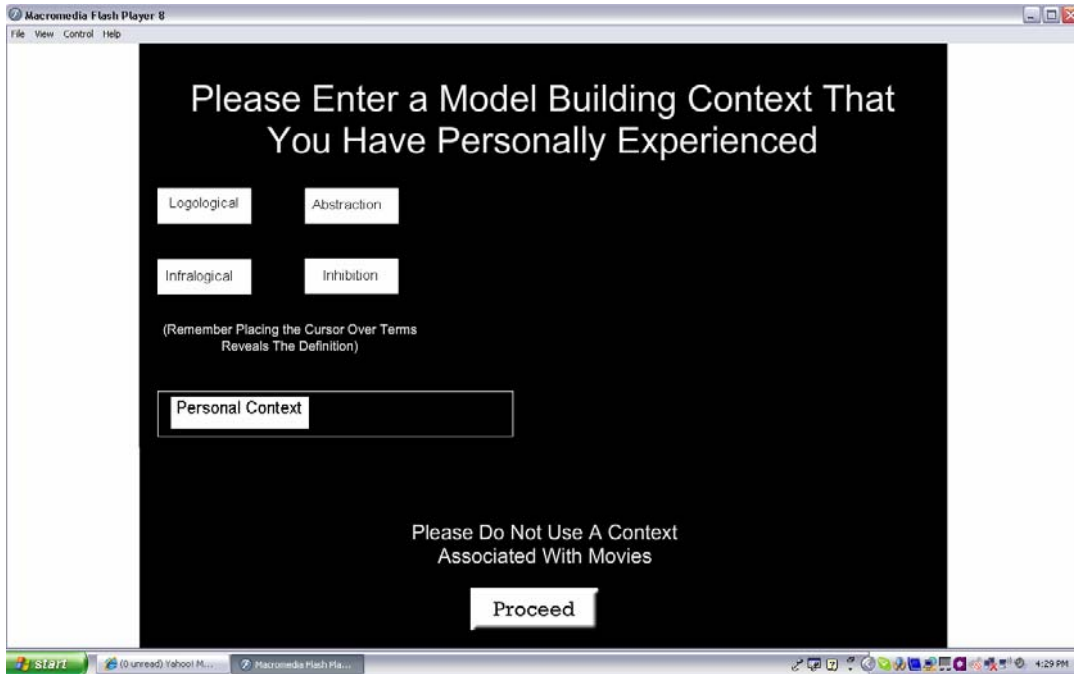
Two reasons are given for elongated retention interval due to longer inter-stimulus intervals. The first reason is termed elaborate retrieval. The theory of elaborate retrieval says that when the same concept is presented after a delay, the person must strain their memory to remember the concept. Thus, a stronger link is made to the concept and as a result, elaborate retrieval is said to make the concept more accessible in the future. As an example, imagine you are trying very hard to remember a concept during an exam, if you look up the answer or if you remember it after thinking about it for a long time, you will tend to retain this answer for a longer period of time. This is the idea behind elaborate retrieval.

The second reason for the improved retention of memory due to spaced practice is termed variable encoding. The theory of variable encoding says that concepts which are spaced, give the person two contexts to remember the concept. Thus, it makes the concept easier to remember at a later date. To give an example of this, if you see somebody like your mail person and you see them in the same context every day you may not recognize this person when you see them out of context, for example, at a formal occasion. However, if you see somebody, like a colleague, in different context every day, you will tend to recognize this person in many different situations.

This is the end of session 3.

Appendix B

Model-Building Screen Shots



Appendix C
Pre-Study Test

1. Which of the following cognitive operations requires the most mental effort?
 - a. logological abstraction
 - b. infralogical abstraction
 - c. automatized learning
 - d. spaced practice

2. The 'packages' of information used to store knowledge in long-term memory are called _____.
 - a. accretions
 - b. cognitive abstractions
 - c. schema
 - d. logic

3. The intensive search for information during spaced practice is termed
 - a. deep retrieval
 - b. cognitive retrieval
 - c. elaborate retrieval
 - d. extensive retrieval

4. Using extensive mental effort to combine information from long-term memory is called?
 - a. intentional learning
 - b. coordinated learning
 - c. constructive learning
 - d. automatized learning

5. Which of the following represents the cognitive process required to learn new information?
 - a. tuning, logological abstraction, inhibition
 - b. inhibition, logological abstraction, tuning
 - c. logological abstraction, inhibition, tuning
 - d. tuning, inhibition, logological abstraction

Appendix D General Knowledge Test

1. The removal of important concepts from large bodies of information
 - a. Abstraction
 - b. Inhibition
 - c. Logological
 - d. Infralogical

Answer

2. Blocking inappropriate memory receptors to ensure only required information is perceived
 - a. Abstraction
 - b. Inhibition
 - c. Logological
 - d. Infralogical

Answer

3. Extensive inhibition used for the acquisition of morals or underlying principles
 - a. Abstraction
 - b. Inhibition
 - c. Logological
 - d. Infralogical

Answer

4. Less extensive inhibition used to extract key points during learning
 - a. Abstraction
 - b. Inhibition
 - c. Logological
 - d. Infralogical

Answer

5. Incorporating new information into existing schemas
 - a. Tuning
 - b. Assimilation
 - c. Accommodation
 - d. Dis-equilibrium

Answer

6. Manipulating newly learnt concepts to conform to current schema
 - a. Tuning
 - b. Assimilation
 - c. Accommodation
 - d. Dis-equilibrium

Answer

7. Adjusting schema to reflect newly learnt concepts
- Tuning
 - Assimilation
 - Accommodation
 - Dis-equilibrium

Answer

8. Contradiction between environmental information and current schema
- Tuning
 - Assimilation
 - Accommodation
 - Dis-equilibrium

Answer

9. Using extensive mental effort to regain forgotten information
- Elaborate Retrieval
 - Retention Interval
 - Inter-stimulus Interval
 - Variable Encoding

Answer

10. The time between learning information and remembering it
- Elaborate Retrieval
 - Retention Interval
 - Inter-stimulus Interval
 - Variable Encoding

Answer

11. The time between the first and second presentation of information
- Elaborate Retrieval
 - Retention Interval
 - Inter-stimulus Interval
 - Variable Encoding

Answer

12. Encoding information in multiple diverse contexts to improve the number of contexts in which it can be remembered
- Elaborate Retrieval
 - Retention Interval
 - Inter-stimulus Interval
 - Variable Encoding

Answer

Appendix E

Knowledge Extension Test

On screen instruction:

Please read the following scenario. When you have finished you will be asked to answer four questions in an essay format. Each section allows for 250 words. We encourage you to use as much space as you can without going over the word limit. Please attempt to write full answers and integrate as much as you can of what you have learned into your answers. Please also include the terminology which was used in the information sessions. Feel free to extrapolate on the information provided and use assumptions which are not discussed in the dilemma.

The Bomb

Officer Adam Blaine is having a very bad day. Today is his first day on the job and although the police academy was excellent training, nothing could have prepared him for the current situation. When he was asked to respond to a bomb scare at the local mall he knew that he was going to be treading unfamiliar waters alone. You see, due to his remote posting, backup couldn't arrive for at least an hour. Upon arriving at the scene he finds a bomb and a timer. The timer shows that there is 30 minutes before detonation and attached to it is a letter with the heading "lift and read". When Officer Blaine picks up the letter, a string triggers the activation device and the timer starts. Surrounding the bomb there is also 10 little pieces of electrical wire. The note reads as follows:

"Electricity is the key to stopping this bomb. With enough current the detonators battery will be short circuited and the timer will stop. However, the amount of current needed to stop the battery, will melt the plastic and the bomb will detonate. You can use the electrical current from your flashlight battery, as it has enough power to short circuit the timer. Read the following stories. The solutions to your current dilemma will be found in these stories, but remember, you only have thirty minutes before complete destruction.

Story 1 - The Commander

A military government was established after the elected government was toppled in a coup. The military imposed martial law and abolished all civil liberties. A tank carp commander and his forces remained loyal to the overthrown civilian government. They hid in a forest waiting for a chance to launch a counterattack. The commander felt he could succeed if only the military headquarters could be captured. The headquarters was located on a heavily guarded island situated in the center of a lake. The only way to reach the island was by way of several pontoon bridges that connected it to the surrounding area. However, each bridge was so narrow and unstable that only a few tanks could

cross at once. Such a small force would easily be repulsed by the defending troops. The headquarters therefore appeared invincible.

However, the tank commander tried an unexpected tactic. He secretly sent a number of tanks to locations near each bridge leading to the island. Then under cover of darkness the attack was launched simultaneously across each bridge. All of the groups of tanks arrived on the island together and immediately converged on the military headquarters. They managed to capture the headquarters and eventually restore the civilian government.

Story 2 - The General

A small country was ruled from a strong fortress by a dictator. The fortress was situated in the middle of the country, surrounded by farms and villages. Many roads led to the fortress through the countryside. A rebel general vowed to capture the fortress. The general knew that an attack by his entire army would capture the fortress. He gathered his army at the head of one of the roads, ready to launch a full-scale direct attack. However, the general then learned that the dictator had planted mines on each of the roads. The mines were set so that small bodies of men could pass over them safely, since the dictator needed to move his troops and workers to and from the fortress.

However, any large force would detonate the mines. Not only would this blow up the road, but it would also destroy many neighboring villages. It therefore seemed impossible to capture the fortress. However, the general devised a simple plan. He divided his army into small groups and dispatched each group to the head of a different road. When all was ready he gave the signal and each group marched down a different road. Each group continued down its road to the fortress so that the entire army arrived together at the fortress at the same time. In this way, the general captured the fortress and overthrew the dictator.

When he finished reading the stories Officer Blaine quickly picked up the wires and attached them to the battery. He then connected the remaining ends of the wire to different locations on the detonator, but ensured that they all pointed at the battery. When the current from all the wires hit the battery at the same time, the battery short circuited and the bomb was neutralized.

From: Gick and Holyoak, 1983

Q2. Using the terminology and concepts from information session #2, on schematic development, explain how Officer Blaine may have adapted the concepts learned in the stories into currently held schemas?

Appendix F
Satisfaction Questionnaire

1. I found the information in this study useful?

Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree

2. I was interested in the material presented in this course.

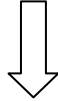
Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree

3. I will be able to use this information in my daily life.

Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree

Appendix G
Model – Building Task
(Approximately 90 Minutes)

Initial Test ~5 minutes
• Entrance Questionnaire



- Animated demonstration of model-building procedure (10 min)
- Narrated information passages (a, b, c) ~ 3 x 4 min = 12 min



Time = 10 x 3 = 30min

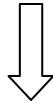
- 1) Participants will construct a schematic model describing how the concepts fit into their experience
- 2) The flowing information/building schedule will be followed
 - a. information 'a' – build model 'a'
 - b. information 'b'
 - c. information 'c' – build model 'b'
 - d. 5 minute break
 - e. build model 'c'



- 1) General knowledge test will be given ~ 10 min
- 2) Knowledge extension test will be given ~ 20 min
- 3) Satisfaction questionnaire ~ 3 min

Appendix H
Free study Task
(Approximately 90 Minutes)

Initial Test ~5 minutes
• Entrance Questionnaire



Narrated information passages – 3 x 4 min = 12 min



Time = 12 x 3 = 36 min

- 1) Participants will study the information provided
- 2) The following information/free study schedule will be followed
 - a. narrated information 'a' – free study 'a'
 - b. narrated information 'b'
 - c. narrated information 'c' – free study 'b'
 - d. 5 minute break
 - e. free study c



- 1) General knowledge test will be given ~ 10 min
- 2) Knowledge extension test will be given ~ 20 min
- 3) Satisfaction questionnaire will be given ~ 3min