Enhancing Knowledge Transfer through Nurturing Cognitive Flexibility

by

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(Under the Direction of Jay E. Aronson)

ABSTRACT

The ability to leverage knowledge has become a core competence of organizations to compete in the contemporary economy. Knowledge management systems using knowledge repositories capture valuable knowledge assets for future reuse. How knowledge can be presented in these systems to support effective knowledge reuse becomes a critical challenge. Knowledge transfer is an essential knowledge reuse process which involves adopting knowledge from its original problem-solving context to a different context, and adapting the knowledge to solve new problems. Adaptation is vital, yet challenging. This problem was explored from the individual knowledge worker's perspective. Integrating the research from the educational psychology and learning literatures, this study posits that a knowledge worker's flexible understanding of the knowledge has a positive impact on the transfer (as in the sense of application) of that knowledge; and that a knowledge worker's flexible understanding of specific knowledge content can be improved through knowledge presentations that emphasize cognitive flexibility. Further, it was purported that in an effective, successful knowledge management system, knowledge should be presented to enhance flexible understanding, and consequently, improve knowledge transfer. The principles of knowledge presentation that promote flexible understandings were explored and used in an experiment. The empirical findings partially confirmed the effect of knowledge presentation on developing flexible understandings. It was found that the effect of knowledge presentation depends on individuals' cognitive traits. This interaction effect and the implications to research and practice are discussed.

INDEX WORDS: Knowledge management, knowledge transfer, cognitive flexibility, knowledge presentation, storytelling, cognitive trait

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Chapter 1: INTRODUCTION

1.1 Background

Knowledge and knowledge management have attracted increasing interest of both the researchers and the practitioners as the ability to leverage knowledge has become a core competence of an organization to compete in the contemporary economy. Knowledge is a fundamental asset for firms. The ability to acquire, integrate, create, and deploy knowledge has emerged as a fundamental organizational capability. To be successful, companies must not only exploit their existing knowledge, but must also invest in continually exploring new knowledge as strategic options for future strategies and competitive advantage (Sambamurthy et al. 2005).

Companies are turning to knowledge management (KM) to leverage and manage their knowledge resources. The analyst firm IDC predicted that business spending on KM could rise from $2.7 billion in 2002 to $4.8 billion in 2007 (Babcock 2004). Concurrent with the organizational interest in KM, a large number of academic papers have been published on KM (Schultze et al. 2002). The objective of knowledge management as a corporate function focuses on the protection of knowledge assets and the exploitation of them (Sutton 2001). The process of knowledge management involves capturing and storing extant knowledge, and retrieving and reusing knowledge in the future. Formally, KM is defined as "a systemic and organizationally specified process for acquiring, organizing, and communicating both tacit and explicit knowledge of employees so that other employees may make sure of it to be more effective and productive in their work" (Alavi et al. 1999, p. 6). Knowledge management includes four types of activities: knowledge creation, storage, retrieval, and application (Alavi et al. 2001b). Each activity is critical yet challenging. Although managing knowledge is not at all a new subject, the exploration for effective knowledge management is at an early stage and calls for much research and practice (Hansen et al. 1999).

Knowledge Management Systems (KMS) is a class of information systems applied to managing organizational knowledge, to the support and enhancement of organizational processes of knowledge creation, storage/retrieval, transfer, and application (Alavi et al. 2001a, p. 114). Companies generally follow two different KM strategies – knowledge repository centered strategy (*codification strategy*) and personal communication centered strategy (*personalization strategy*) (Hansen et al. 1999), or, the repository model and the network model (Alavi 2000). The repository model supports codification and storage of knowledge so as to facilitate knowledge reuse through access to the codified expertise. The network model focuses on facilitating person-to-person transfer of knowledge via electronic communication channels. KM projects that employ the personalization strategy underline the exchange of tacit knowledge through socialization by enabling person-to-person communication and collaboration. They usually use methods such as discussion forums, newsgroups, and video conferences. KM projects that employ the codification strategy underline the externalization and reuse of knowledge. Knowledge repositories are usually used to support this strategy. The knowledge in the repositories is disseminated via intranets and email systems. Hansen et al. (1999) suggested that when the knowledge is relatively easy to codify without losing much tacit knowledge, the codification strategy is effective and leads to cost efficiency as a result of knowledge reuse. This strategy is suitable for similar problems and repetitive activities. Companies whose competitive advantage lies in product/service standardization and efficiency usually find this strategy effective. On the other hand, when the knowledge is highly tacit and difficult to codify, then the personalization strategy is more suitable than the codification strategy. Companies whose competitive advantage lies in high level customization and innovation need to encourage rich person to person communication to ensure tacit knowledge get successfully transferred and applied. It is unwise for firms to either straddle over both strategies or completely abandon one strategy over another. The best practice is to choose and focus on one strategy while using the other to support it (Davenport et al. 1998b; Hansen et al. 1999).

1.2 Research Question

The knowledge-based view of the firm (Nonaka, Toyama, and Nagata 2000) suggests that the capability to create and utilize knowledge is the most important source of sustainable competitive advantage. It follows that KM practice should support and enhance knowledge application (Alavi 2000). Knowledge application is defined in the KM literature as "the use of knowledge for decision-making and problem-solving by individuals and groups in organizations" (Alavi et al. 2003, p. 111). Knowledge transfer (KT) is a particular type of knowledge reuse that requires the restructure and incorporation of prior knowledge and the adaptation to the problem at hand. Formally, KT refers to the adoption of knowledge from its original problem-solving context to a new context, and the adaptation of the knowledge to create a solution under the new conditions. KT has attracted growing research interest (Carlile and Rebentisch 2003).

Prior research has reported that while the ability to reuse knowledge contributes to organizational performance (Argote and Ingram 2000), knowledge reuse is nontrivial, and maintaining and recreating a set of routines in a new setting is extremely challenging (Szulanski 2000). At the heart of this challenge is the adaptation to new requirements in new situations. Many factors contribute to the challenge of KT. A primary one is related to the nature of knowledge. Knowledge is true belief (Nonaka 1994), therefore, it is up to individual knowledge workers to have it and make it his or her basis for action. Yet, part of knowledge is tacit and hard to communicate (Polanyi 1966). Knowledge is context-embedded and dynamic (Carlile et al. 2003).

Up to date, researchers have been searching for ways to effectively maintain existing knowledge to create new knowledge and apply it. Knowledge management is an organizational practice to maintain and transfer knowledge for future use. Research about individual knowledge transfer is needed to improve its effectiveness, and consequently, the effectiveness of KM. This study focuses on one aspect of knowledge management – the presentation of existing knowledge, and its relationship to individual learning to develop guidelines for knowledge presentation that enhance the effectiveness of KT.

Alavi (2000) suggested borrowing from the psychology literature to investigate knowledge utilization through individuals' cognitive processes (problem solving and decision making). Following this suggestions, I tackled the challenge of KT from a cognitive perspective. The goal was to identify cognitive factors that are critical to KT, and establish a set of principles of knowledge presentation that promote these cognitive characteristics, and thus lead to the development of highly successful knowledge management systems. In particular, the following research questions were addressed in this study:

1. What cognitive factors affect the effectiveness of KT?

2. What characteristics of knowledge presentations influence these factors?

Drawing from the educational psychology and end-user training literatures, it is purported that (1) a knowledge worker's flexible understanding of the knowledge content is positively related to the effectiveness of KT, (2) a knowledge worker's flexible understanding of the knowledge content can be increased by emphasizing flexibility understanding in the learning process and that properly designed knowledge presentations should help to build flexible understanding of the specific knowledge content.

1.3 Overview of Methodology

A research model was developed, and hypotheses were drawn regarding knowledge presentation, individual cognitive traits, flexible understanding the knowledge content, and KT effectiveness. A laboratory experiment was conducted to collect the data needed for the analysis. The treatment was knowledge presentations that were designed following principles that promote flexible understanding. A control group was used for the assessment of baseline performance. Knowledge presentations that covered the knowledge to be imparted in the experiment but were not designed with the emphasis on flexible understanding were used for the control group. A total of 194 undergraduate students took part in the experiment, the data from 184 of the 194 subjects were used in the analysis, due to invalid or missing data. Regression, Multiple Analysis of Covariance (MANCOVA), and Analysis of Variance (ANOVA) techniques were used to analyze the experimental data.

1.4 Importance of Research

While it is widely accepted that unstructured and tacit knowledge is important for an organization to compete in the modern business world, and that KM provides the platform and tools to save and share knowledge, the literature is scant on the provision of guidelines for capturing and storing unstructured knowledge. With KM studies at the organizational level proliferating, the room for research on KT at the individual level remains large. While acknowledging the importance of the organizational approach, this study investigate the issues of KT at the individual level, as ultimately knowledge workers' are the ones who learn, apply, and contribute to knowledge creation, and individually held expertise is critical to team level creativity (Tiwana et al. 2005).

This study contributes to a better understanding of KT at the individual level. It was found that flexible understanding can be nurtured as a result of carefully designed learning. Knowledge presentations can be designed to help develop a flexible understanding of the knowledge content. Certain principles are developed for the creation of learning materials. One set of principles originated from the Cognitive Flexibility Theory (CFT) in the educational psychology research. Other principles concern the individual cognitive traits. It was found the impact of knowledge presentation on flexible understanding depends on the individual's cognitive style, and possibly the individual's learning style. In addition, cognitive traits have very strong and dominating effect in developing a flexible understanding of the specific knowledge content. When the characteristics of the knowledge presentations do not fit an individual's cognitive style, the characteristics of the knowledge presentation may hinder the individual from developing a flexible understanding. On the other hand, when the characteristics of the knowledge presentations do fit an individual's cognitive style, he/she tends to develop a flexible understanding of the knowledge presented in the materials.

These findings are important to both research and practice in that (1) they suggest that knowledge presentation has important impacts on the transfer of knowledge, and consequently should be given sufficient attention to assure effective knowledge transfer; (2) the findings confirm that certain dimensions of knowledge presentation are influential in building flexible understanding, and that the principles suggested in the learning literature to nurture cognitive flexibility are in fact effective to developing flexible understanding; and (3) the findings point out the importance of individual knowledge workers' cognitive traits, and emphasize the fit between the characteristics of knowledge presentation and individuals' cognitive traits.

1.5 Organization of the Dissertation

The rest of the proposal is organized as follows: in Chapter 2, the literature in related fields is reviewed for prior important work; in Chapter 3, the research model is developed and the hypotheses are drawn for the causal links between knowledge presentation and flexible understanding of specific knowledge content (FLUKC), and between FLUKC and effective KT; in Chapter 4, the research method used for collecting the data needed for the study and the statistical techniques used for analyzing the data is discussed; in Chapter 6, the results of hypothesis testing are presented; in Chapter 7, the findings are summarized, with highlights of the findings and a discussion of the limitations of the work, and the dissertation is concluded with a discussion of the implications to research and practice.

Chapter 2: LITERATURE REVIEW

This chapter is presented in four sections. The first section deals specifically with the definition of knowledge transfer, and discusses the importance of KT and the difficulties to transfer knowledge. The second section brings in the educational psychology research and introduces the concept of Cognitive Flexibility (CF) as an important determinant of effective knowledge transfer at the individual level. The third section introduces Cognitive Flexibility Theory with regard to how to increase CF in learning. The fourth section introduces stories as a method of passing on unstructured and tacit knowledge.

2.1 Knowledge Transfer

2.1.1 The Definition

The view of knowledge is adopted from the theory of knowledge creation (Nonaka 1994). Knowledge is considered as "justified true belief." As noted in Nonaka (1994), this view of knowledge acknowledges several points: one, knowledge is justified and held by the knowledge holder; two, knowledge is dynamic; three, knowledge is the basis for action.

In the KM literature, knowledge transfer refers to a process that involves two activities – the flow of knowledge from a source end to a receiving end, and the exploitation of the knowledge at the receiving end. Some use the term with an emphasis on one of the two activities, some on both. KT has been used to refer to the process that knowledge is being transmitted from where it is created to where it is needed and applied (Alavi et al. 2003). In this sense, KT refers to the flow of knowledge and may happen in three modes in a knowledge management system: from individual to individual, from individual and knowledge repositories (both downloading and uploading), and from repository to repository.

Obtaining knowledge does not necessarily lead to its absorption and use by the recipient (Alavi 2000). While some research use the term KT to refer to the movement of knowledge from its source to recipient, and not necessarily the application of the knowledge, e.g., Alavi (2000) and Lin et al. (2005), others use the term in a way that involves the application of the transferred knowledge (Davenport et al. 1998b). For instance, Davenport and Prusak (1998b) hold that absorption and use are part of knowledge transfer. Nevertheless, knowledge utilization at the receiving end attracts substantial attention in the discussion of KT at both the organizational and individual level. After all, obtaining knowledge from a knowledge source is only one step towards creating value for an organization, using it properly is not any less important. In line with this argument, Szulanski (2000) considers knowledge transfer a process in which an organization recreates and maintains a complex, causally ambiguous set of routines in a new setting. Ko, Kirsch, and King (2005) defines KT as "the communication of knowledge from a source so that it is learned and applied by a recipient." Our interest of KT primarily concerns the adaptation of knowledge from an original problem context to a new context at the individual level. KT is defined as *the adoption of knowledge from its original problem-solving context to a new context, and the adaptation of the knowledge to create a solution under the new conditions*. This definition is consistent with the way the term is used by the KM researchers as well as the education researchers (Argote et al. 2000a; Carlile et al. 2003; Szulanski 2000). This definition makes it clear that, as far as it is concerned, KT involves two activities, namely, the learning process and innovative use of the knowledge. By "innovative using" it means that it is expected that one cannot directly apply the learned knowledge, instead, one must adapt the knowledge to what the situation demands.

2.1.2 The Importance and Challenges

The primary technical approach to organizational knowledge storage and retrieval depends on collaboration technologies that applies knowledge repositories which bring together content from various data sources, providing a unified access point and reducing knowledge search costs. Repositories can store highly structured content such as transactional data, customer records, and financial information, or relatively unstructured content, such as multimedia content and conversational discussion threads. Web-based data warehouse, which integrate content from several distributed databases, are perhaps the most common from of repositories among contemporary organizations. Repositories for unstructured content allow for the storage and retrieval of unstructured content that fosters knowledge sharing both internally and with customers. For example, Dell, the computer hardware manufacturer located in Austin, Texas, uses a repository to facilitate knowledge storage for customers and its technical support staff. When a customer is faced with a specific problem, he or she can search a repository of the “frequently asked questions” for a solution. If a similar problem was previously addressed, the repository can immediately provide a possible solution. If no solution can be retrieved from the repository, posting the query can elicit troubleshooting suggestions from Dell’s support staff who continually monitor this repository. By storing and reusing knowledge in the form of the solutions to frequently encountered problems, Dell is able to reduce the overhead of providing technical support to customers (Alavi et al. 2003).

Knowledge brings value when it is applied by organizations to create capabilities and take effective action, yet, knowledge transmission does not necessarily lead to its absorption and use by the recipient (Alavi 2000). Effective knowledge transmission from its source to recipient is only the first step toward effective organizational knowledge utilization. Knowledge transfer is difficult for a lot of reasons, an essential one is that part of knowledge is tacit. The fundamental puzzle first stated by Michael Polanyi (Polanyi 1966) that individuals know more than they can explain has broad implications for the difficulty of transferring knowledge (Kogut et al. 1992).

Szulanski (2000) states that knowledge is “sticky” and difficult to transfer. The “stickiness” comes from several sources. First, it is challenging for the source to completely articulate the knowledge, and it is equally challenging for the recipient to accurately specify the environment where new knowledge will be applied. Therefore, the recognition of an opportunity for knowledge transfer is jeopardized. Second, transferring complex and causally ambiguous knowledge especially requires reconstruction and adaptation at the receiving end. Causal ambiguity could result from imperfectly understood idiosyncratic features of the context in which knowledge is put to use. Tacitness could result from the indefinable portion of knowledge that is embodied in highly tacit human skills, tacitness could also be a property of collectively held knowledge (Szulanski 1996). In general, when context changes leads to new requirements and novel conditions, they form a core challenge to knowledge transfer (Carlile et al. 2003).

The Absorptive Capacity (ACAP) literature suggests that the ACAP of the receiving end may introduce additional challenges to assimilating obtained knowledge. Absorptive Capacity is defined as the “ability to recognize the value of new information, assimilate it, and apply it to commercial ends”(Cohen et al. 1990, p. 128). Cohen and Levinthal suggest that the level of prior related knowledge and diversity of background enhance absorptive capacity. It can be argued that if the receiving end does not have sufficient level of related knowledge and experience, then it may not have sufficient capability to recognize and assimilate the new knowledge.

2.2 Cognitive Flexibility

Reusing knowledge involves analyzing general principles or de-contextualized knowledge against a specific situation – a process sometimes called the “re-contextualization” of knowledge (Markus 2001). KT is called for when relevant prior knowledge is not already organized to fit a problem and therefore must be assembled from different knowledge sources in memory (Spiro et al. 1990; Spiro et al. 1987). KT is oftentimes challenging because transferring knowledge requires reconstruction and adaptation at the receiving end (Carlile et al. 2003; Szulanski 2000). It follows that to be effective in KT, one’s knowledge structure should not be rigidly attached to a particular system or situation, on the contrary, a knowledge structure effective for KT should support knowledge application according to the specific conditions of a situation. In educational psychology, knowledge structures with this characteristic are labeled cognitively flexible.

Educational psychology suggests that cognitive flexibility (CF), defined as “the ability to spontaneously restructure one’s knowledge, in many ways, in adaptive response to radically changing situational demands ...” (Spiro et al. 1990), is crucial to KT. CF refers to a person’s ability to use a concept effectively in a variety of situations as a result of knowing the concept in its full complexity (Kolodner 1997), and the ability to relate the same concepts in different ways when the concepts are embedded in two different conceptual frameworks (Naveh-Benjamin et al. 1998). CF is reported to be positively related to academic performance, and can be improved by using appropriate instructional methods (Jacobson et al. 1995; Naveh-Benjamin et al. 1998; Spiro et al. 1991a; Spiro et al. 1991b; Spiro et al. 1990).

A closely related concept is cognitive complexity. In a study of communication competence, cognitive complexity refers to the ability to perceive interactive relationships (Roy 2001). Mostly however, whereas complexity is more closely associated with content, flexibility is more directly related to the relations among the concepts within the content. For instance, cognitive complexity is described as "the number of independent dimensions-worth of concepts the individual brings to bear in describing a particular domain of phenomena," and cognitive flexibility as "the readiness with which the person's concept system changes selectively in response to appropriate environmental stimuli" (Scott 1962).

The term CF has also been used to refer to individual trait, for instance, CF was considered a component of general cognitive ability or intelligence (Battig 1979; Carroll 1988). In this study, it is 'CF with respect to specific knowledge content' that is at the center of interest because the ultimate goal of this study was to build guidelines for knowledge presentations in KMS to enable and enhance knowledge transfer. According to prior research, CF with respect to specific knowledge can be improved through learning that emphasizes flexibility (Jacobson et al. 1995; Naveh-Benjamin et al. 1998; Spiro et al. 1991a; Spiro et al. 1991b; Spiro et al. 1990), whereas individual trait is much more consistent across situations and over time (Bostrom et al. 1990). To differentiate CF which is the concern in this study and that refers to the cognitive individual trait, the former is referred to as 'flexible understanding of the knowledge content' (FLUKC) while the latter is referred to as 'general CF' in the rest of this document. General intelligence, on the other hand, is an important individual cognitive characteristic that affects learning and knowledge work. It was included in this study as a covariate.

A discussion of CF (both general CF and flexible understanding of specific knowledge content) and absorptive capacity (ACAP) in regard to their difference and similarity seems worthwhile.

ACAP refers to the ability to recognize, assimilate, and apply new information to commercial ends (Cohen et al. 1990; Lane et al. 2006; Zahra et al. 2002). CF and ACAP are similar in that, they both denote the capability to utilize existing knowledge to create new knowledge. ACAP is similar to creative capacity and concerns assimilating existing knowledge (learning) and creating new knowledge. CF concerns how knowledge should be acquired and organized to facilitate a wide range of future applications. The antecedents of CF and ACAP are similar as well. Cohen and Levinthal (1990) emphasize the importance of prior knowledge and the diversity of background for learning. In the case of problem-solving, prior knowledge is typically constituted of "problem-solving methods and heuristics"(Cohen et al. 1990, p. 130). Borrowing from the psychology and learning literature, Cohen and Levinthal suggest that ACAP depends on the "richness of the preexisting knowledge structure," and "the more processing makes use of associations between the items to be learned and knowledge already in the memory." Similarly, Cognitive Flexibility Theory suggests that CF can be increased by exposing multiple rather than single conceptual dimensions to a learner, and by going through a learning process during which schemas (intact knowledge piece) are taken apart and reassembled in the learner's head.

The major difference between CF and ACAP is their focus of research context. Despite its origin as an individual's cognitive characteristic, the concept of ACAP has been introduced with a primary interest in organizational innovation capability. Such an organizational research focus has lead to research questions and constructs that are different from individual-level research, such as this dissertation. Cohen and Levinthal (1990) focused on how firms' investments in R&D affect their innovative capabilities. Zahra and George (2002) view ACAP as a dynamic capability of an organization which is strategic in nature and affects organizational change. The latest revisit of the construct highlights the commercial and knowledge outcomes of ACAP and the antecedents of ACAP such as a firm's environment, policy, structure, and processes (Lane et al. 2006). On the other hand, CF as used in this paper is an individual characteristic pertaining to a set of knowledge. Our interest is in how CF may improve knowledge reutilization at the individual level. Educational psychology and learning theories underlie the antecedents and relationships concerning CF.

An interesting and relevant question is how to enhance flexible understanding of specific knowledge content. I turned to the following research areas to address this question, namely, Cognitive Flexibility Theory (Spiro et al. 1987), Experiential Learning Theory (Kolb 1984), and Case Based Reasoning (Hernandez-Serrano et al. 2003; Kolodner 1997).

2.3 Cognitive Flexibility Theory

The instructional psychology research recognize the importance of flexible understanding to knowledge transfer, theories have been developed about how to improve FLUKC as an outcome of instructional efforts. The cognitive structure of material learned has been assessed as diagnosis for learning. Cognitive structure is considered a property of both sides of learning (Naveh-Benjamin et al. 1998). On the teaching side, instruction may vary on the structural dimension. On the outcome side, cognitive structure of materials learned refers to "the way in which students initially organize and represent knowledge and the ways their knowledge representations are modified by new knowledge." The cognitive structure of materials learned is related to "whether students are able to relate the same concepts in different ways when the concepts are embedded in two different conceptual frameworks" and "the ability to use different underlying dimensions when evaluating the relationships among various concepts in the course."

Naveh-Benjamin et al. (1998) showed that the latter can be affected by course materials that provide different perspectives and emphasize their interconnections.

Cognitive Flexibility Theory (CFT) (Spiro et al. 1987) is an eminent work on cognitive flexibility and is widely cited in educational and instructional research. CFT addresses how knowledge should be acquired and organized to facilitate a wide range of future applications. The researchers of CFT (Spiro et al. 1988) stated that CFT provides principled recommendations for the development of instructional systems to promote successful learning in ill-structured knowledge domains. As opposed to well-structured knowledge domains, where the application of general principles and abstract concepts can proceed in a routinized manner, ill-structured knowledge domains are characterized by the following two properties: 1) each case or example of knowledge application typically involves the simultaneous interactive involvement of multiple, wide-application conceptual structures, each of which involves concept- and case-complexity; and 2) the pattern of conceptual incidence and interaction varies substantially across cases nominally of the same type (i.e., the domain involves across-case irregularity).

Acknowledging the constructive nature of learning, CFT is a theory of case-based learning. CFT suggests that, just as a full appreciation of the nuances of a landscape emerges after "crisscrossing" the terrain from different geographical perspectives, a rich and flexible understanding of a complex conceptual landscape will emerge only after the learner has made numerous traversals of the domain from different intellectual perspectives. A central claim of CFT is that avoiding inappropriate instructional over-simplifications contributes to improved learning and transfer of complex knowledge (Jacobson et al. 1995).

CFT considers FLUKC a function of both the way knowledge is presented (e.g., along multiple rather than single conceptual dimensions) and the processes that operate on learners' mental models (e.g., processes of schema assembly rather than intact schema retrieval). CFT provides the following principles regarding the design of learning materials and learning processes: (1) learning activities must provide multiple representations of content; (2) instructional materials should avoid oversimplifying the content domain and support context-dependent knowledge; (3) instruction should emphasize knowledge construction, not transmission of information; and (4) knowledge sources should be highly interconnected rather than compartmentalized.

2.4 Storytelling as a Means of Knowledge Transfer

Stories have long been used to convey knowledge and wisdom. For thousands of years, every culture has had rich stories that pass on their unique values and traditions from generation to generation. Relatively recently, stories are rediscovered as a means to capture and communicate knowledge that is difficult to structure and codify. Tacit knowledge is highly embedded in the minds of people and hard to codify and make explicit. Narratives and rich communications are needed to transfer tacit knowledge (Alavi 2000). Moreover, as common definitions of terms are necessary to build a common ground to facilitate the sharing of knowledge, valuable local distinctive attributes should not be lost in the process of knowledge codification; yet, it is very challenging to codify knowledge and still leave its distinctive attributes intact (Davenport et al. 1998a).

Stories lend themselves as a perfect means to capture the richness of events, keep subtle distinctive aspects, and provide multiple perspectives. Stories of the same event told by different persons provide different facets, these different perspectives of the same events, help listeners to compile a more comprehensive picture. Stories can convey lived experience that engages listeners in the events, the uncertainties, mistakes and misunderstandings, and interconnectedness of the phenomenon (Cox 2001).

The theory of Case-Base Reasoning (CBR)* (Kolodner 1997) provides a theoretical basis for using stories in knowledge transfer. CBR purports that cases in the form of stories are useful for supporting problem solving by focusing the novice's attention on what is important, making available ideas on how to move forward, and giving grounds for pre-assessing the consequences of their decisions or actions. The process of understanding and solving new problems in terms of previous experiences has three parts: recalling old experiences, interpreting the new situation in terms of the old experience based on the lessons that were learned from the old experience, or adapting the old solution to meet the needs of the new situation. Given the lack of previous experiences among novices, substitute experiences available through a case library are expected to augment learners' repertoires of experiences by connecting to the experiences of others (experts), forewarning potential problems, realizing what to avoid, and foreseeing the consequences of decisions or actions. Knowledge repositories are created for similar objective.

In summary, built on previous work, the following points were illustrated in this chapter. One, knowledge transfer or KT, i.e., the adoption and adaptation of knowledge, is often challenging and requires flexible understanding of the knowledge content, the ability to adjust in response to

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* This notion of CBR is different from that used in artificial intelligence.

situational demand. The tacit dimension of knowledge contributes to this challenge. Two, a flexible understanding can be developed following instructional principles suggested by Cognitive Flexibility Theory (CFT), which is a theory of case-based learning. Three, as tacit knowledge is difficult to codify, stories offer a natural means to capture and communicate tacit and unstructured knowledge.

Chapter 3: CONCEPTUAL MODEL

In Chapter 3 I lay out the theoretical foundation of this research and develop a conceptual model connecting learning methods to knowledge transfer (KT). A general framework of learning is introduced in section 3.1. In section 3.2, I discuss relevant individual difference variables that affect learning. In section 3.3, I develop a conceptual model using the Cognitive Flexibility Theory (CFT) and draw propositions.

3.1 A Framework of Learning

As suggested by educational psychology, flexible understanding of specific knowledge content can be improved by using appropriate instructional methods. Building on cognitive psychology and educational psychology, Bostrom, Olfman, and Sein (1990) provided a framework of end-user training. In this framework, learning is viewed as a process in which learner forms and reforms mental models of the learning target, through forming increasingly sophisticated mental models where each reflects a more adequate understanding of the learning target. A mental model is *the learner's internal representation of the structure and function of the learning target* that provides explanatory and understanding power. The framework postulates that that training methods, individual difference, and the learning target itself influence the formation of the mental model. Correct mental models consistently lead to accurate interaction with the system and subsequently, high levels of task performance. Training methods refer to the set of materials and activities that are designed to impart target knowledge. Individual differences interact with training methods to affect learning outcomes. The framework is depicted in Figure 1.

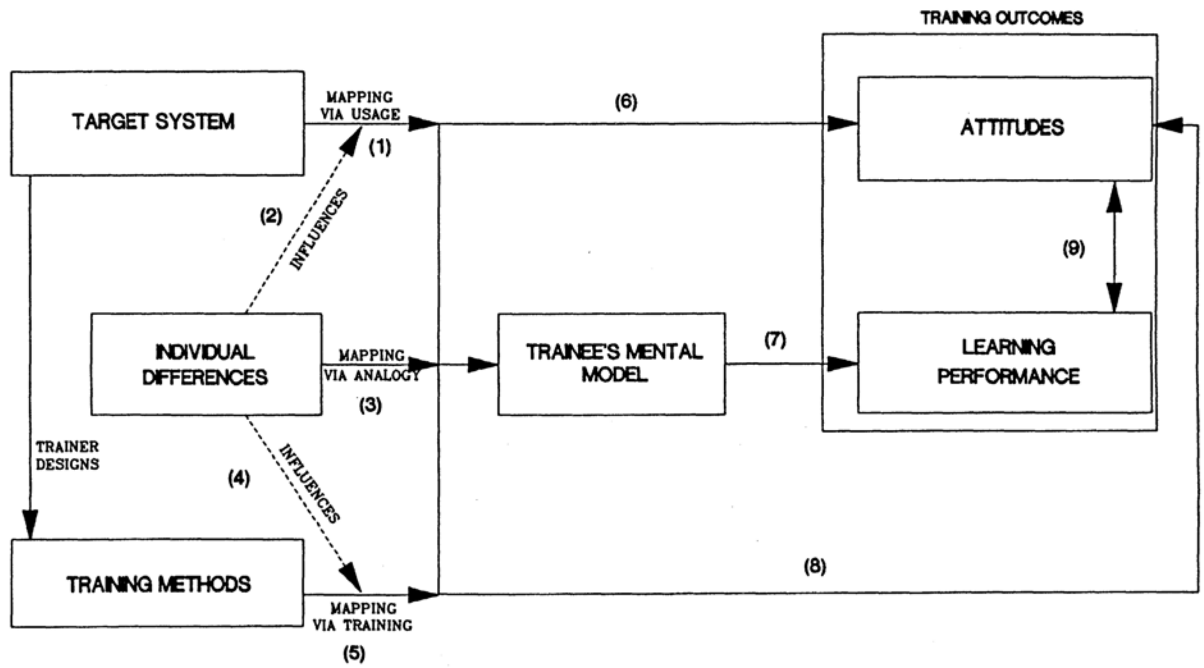


Figure 3-1. Bostrom et al.'s (1990) Framework for End-user Training

Although Bostrom et al.'s (1990) framework focuses on training context, the major constructs and their interrelationships suggested in the framework are consistent with some of the most well-established ideas in educational and psychological research. For instance, a model (Furnham 1995) that is "implicit in the writings of many educational and psychological researchers" illustrates that teaching methods are independently related to cognitive and learning styles and academic achievement in so much as there may or may not be a fit between the methods and the cognitive and learning style. Therefore, Bostrom et al.'s (1990) framework is appropriate for learning contexts that are not confined to training, such as the learning environment within a KMS system. In the generalized learning context, training methods refer to the method by which learners learn (Gupta et al. 2006), which is named "learning method" in our research.

Consistent with the definitions in Bostrom et al.'s (1990) framework, flexible understanding of specific knowledge content is an attribute of learner's mental model, which can be influenced by learning materials, and can influence task performance that requires knowledge transfer. For instance, a mental model can be rigid or flexible, and according to the CF research, rigid representations, characterized by compartmentalized knowledge and little connection between concepts manifested in different situations, provides limited support to KT.

According to CFT, learning methods, or the set of materials and activities that are designed to impart target knowledge, can be designed to develop high level flexible understanding of specific knowledge content. More specifically, Bostrom et al.'s (1990) learning framework and CFT together suggest that learning methods characterized by crisscross learning can enhance the flexible understanding of the knowledge content of learner's mental model.

3.2 Individual Difference Variables

Individual differences are important covariates in the study of learning and problem-solving task performance. For instance, the general intelligence factor *g* positively correlates with academic achievement and job performance. Drawing from Posner and McLeod (Posner et al. 1982), Bostrom et al. (1990) conceptualized individual differences along two dimensions – specificity and dynamics. In the resulting quadrant dichotomizing the two dimensions, individual **traits** have general influences on a wide range of tasks and are enduring over time. In contrast, other individual differences may be task-specific and vary in response to different situations. For instance, **strategies** are task-dependent rather than general and static. Elementary operations may be assembled into sequences and combinations that represent the strategy developed for a particular task. Individual traits can be differentiated into two broad categories: cognitive and affective. This study focuses on cognitions and related individual cognitive traits.

Three individual cognitive trait variables are included in this study as these traits affect learning, problem solving, and IS design. These variables are cognitive style, learning style, and general intelligence. According to Bostrom et al.'s (1990) learning framework, individual difference variables affect the formation of mental models both directly, and indirectly through interactions with learning methods. This section discusses each of these cognitive trait variables.

3.2.1 Learning Style

Learning style is a cognitive trait manifested in learning behaviors. It is an individual's characteristic manner or preference in learning. Learning style theories suggest that an individual's learning style affects his/her learning. Research has suggested adapting educational strategies and instructional methods in response to individual cognitive differences can and has lead to educational improvement (Snow 1986). Particularly, Bostrom et al. (1990) reported that a person's learning style both directly and indirectly (through interaction with training methods) affect learning outcomes.

The Experiential Learning Theory (ELT) (Kolb 1984; Kolb et al. 1975) is widely used in research in learning process, person-job interaction, management education, managerial problem solving, and in practical IS applications such as project team formation (Bostrom et al. 1990). ELT considers learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (Kolb 1984, p.41). Ideally, learning constitutes a cycle of four stages: **experiencing** or concrete experiences are followed by **reflecting** or reflections and observations, reflections provide a basis for **thinking** or abstract conceptualization, which creates concepts and theories that guide actions or **doing**, which, in turn, create new experiences. ELT considers concrete experience (CE) and abstract conceptualization (AC) as two experience-grasping modes that stand in opposition to one another on the ***Perception Continuum***, and reflective observation (RO) and active experimentation (AE) as two experience-transforming modes that stand in opposition to one another on the ***Processing Continuum***. ELT posits that one cannot use two modes that are opposite to each other simultaneously, therefore, a person confronted with a particular learning situation chooses either CE or AC to grasp experience, and either RO or AE to transform experience. Along a single dimension of the perception and processing continuum, learning styles can be represented by the preferred learning mode: abstract vs. concrete, and active vs. reflective. Combining the two dimensions, the preferences on the perception and processing continuum produces four learning styles: **Accommodators** prefer CE and AE, **Divergers** prefer CE and RO, **Assimilators** prefer RO and AC, and **Convergers** prefer AC and AE. Figure 2 depicts Kolb's four learning styles.

Kolb (Kolb et al. 1975) contends that although an individual may prefer different learning style according to the learning situation, an individual's learning style is relatively stable over time and will remain constant within a particular context.

3.2.2 Cognitive Style

Cognitive style is individual preferences in ways of organizing information (Kirton et al. 1986). Unlike FLUKC (defined as being associated with specific knowledge and can be influenced as a learning outcome), cognitive style is an individual trait variable which is stable across time and situations, independent of levels in abilities, skills, or cognitive complexity. The

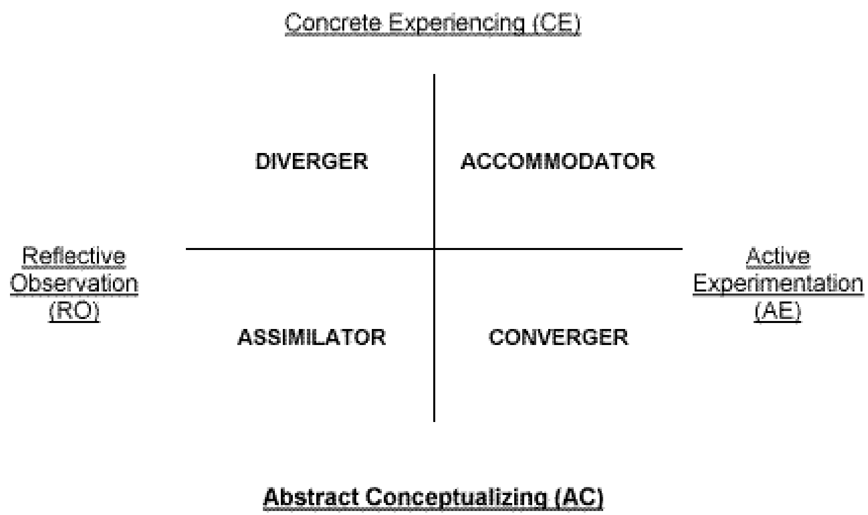


Figure 3-2. Kolb's Learning Styles (Kolb 1984)

Kirton's Adaption-Innovation Theory (KAI) (Kirton 1976) identifies two extreme cognitive styles manifested in creativity, problem-solving, and decision-making behavior – the *habitual adaptor* and *habitual innovator*. Characteristically, adaptors when confronted with a problem turn to conventional procedures and derive ideas towards the solution from established procedures. Innovators on the other hand, characteristically attempt to reorganize or restructure the problem, and to approach the problem from a new angle. Our study concerns one's ability to creatively re-construct knowledge, on which cognitive style may have systematic impacts.

Previous IS literature point out that the discussion of individuals' cognitive style is valuable to the design of MIS in that it precedes the creation of computer systems that fit or complement user's preferred style (Robey 1983). Our usage of the cognitive style construct with respect to its connection to the IS design literature can be summarized in the following two points. First, CS is used as an individual difference variable in our model. As suggested by Huber (1983), people's cognitive style affects their preferences concerning how a system should be used. Hence, it is very likely that CS will influence the system usage outcome, which in this study, is the performance of KT. Second, from the design point of view, I seek to add to the understanding of the fit between CS and knowledge presentation, a particular KMS design issue. Consequently, I hope to draw guidelines of how a KMS can be designed to supplement or complement certain CS. For instance, I predict that flexible knowledge presentations may help 'adaptors' to form higher cognitive flexibility regarding the knowledge learned, which is a characteristic that is assumed to be positively related to KT.

3.2.3 General Intelligence

General intelligence measures an individual's general learning and problem solving capability. As cited in Naveh-Benjamin et al. (1998), some research considers cognitive flexibility a component of general intelligence. Cognitive flexibility has been discussed as an individual difference variable which incorporates two major aspects: (1) the availability in the individual's repertoire of a large number and wide rage of alternative types of strategies or processes and (2) the ability to select the one or more of these alternatives that are most appropriate and effective for the required task or problem. This flexibility was suggested to be accountable for the "within-individual differences" in strategies or processes that an individual uses in learning and problem solving (Battig 1979). The differences between this general cognitive flexibility and flexible understanding of specific knowledge content are that (1) the former is an individual trait variable which is not subject to easy change and (2) while the former is a general trait, the latter is associated with specific knowledge. For example, an individual can have very flexible knowledge of carpentry but very rigid knowledge of computer. I argue that, going through the same learning process, an individual with high general CF (a component of intelligence) tends to develop more flexible understanding of the knowledge learned in the learning process than an individual with low general CF.

It is worthwhile to clarify that in our model general intelligence impacts knowledge specific cognitive flexibility and not vice versa. The research in psychology has studied general intelligence (g) as a dependent variable which is affected by individual difference such as personality. In those studies, general intelligence typically was measured by performance on cognitive ability tests such as IT test, or surrogated as creativity, logical reasoning, and school achievement. Moutafi, Furnham, and Tsaousis (2006) reported that the research since 1980 suggested that intelligence is related to various sub-dimensions of personality such as neuroticism (tendency to experience negative emotions), openness to experience, and extraversion. As a general indicator of cognitive ability, intelligence is not affected by one specific piece of knowledge that is conveyed in our experiment, at least not to a significant level.

A summary of the major constructs and their definitions used in this study is provided in Table 1.

Table 3-1. Definition of Major Constructs

Construct	Definition
Flexible Understanding of the Knowledge Content (FLUKC)	The ability to spontaneously restructure one's knowledge in adaptive response to changing situational demands.
Knowledge Transfer (KT)	The adoption of knowledge from its original problem-solving context to a new context, and the adaptation of the knowledge to create a solution under the new conditions.
Learning Materials (LM)	The set of materials and activities that are designed to impart target knowledge.
Learning Style (LS)	A cognitive trait manifested in learning behaviors. It is an

	individual's characteristic manner or preference in learning.
Cognitive Style (CS)	Consistent individual preference for ways of organizing information.
General Intelligence (GI)	One's general learning and problem solving capability.

3.3 Conceptual Model and Propositions

Based on the previous discussion, a conceptual model is developed which links learning presentations to KT, mediated by a knowledge worker's flexible understanding of the knowledge (FLUKC) to be conveyed. The model postulates that using learning materials designed to emphasize flexible understanding, a learner may develop more flexible understanding of the knowledge content. In turn, more flexible understanding of the knowledge content tends to enhance KT. The model also postulates that an individual's cognitive style, learning style, and general intelligence affect his/her FLUKC both directly and through the interaction with learning materials. The model is depicted in Figure 3.

3.3.1 Main Effects

As pointed out in various literatures, having flexible understanding means that knowledge components are not stored rigidly in rote memory, instead, they were grasped in association with many different contexts and from many different perspectives, hence understood in different relations (Kolodner 1997; Spiro et al. 1988; Spiro et al. 1990; Spiro et al. 1987) . Consequently, CF provides a large number of loosely coupled yet well-connected, and easily re-organized knowledge components. Therefore, when problem-solving calls for knowledge transfer, CF is crucial, as the ability to see and relate concepts flexibly and restructure one's knowledge according to situational demands will be very important to the adoption and

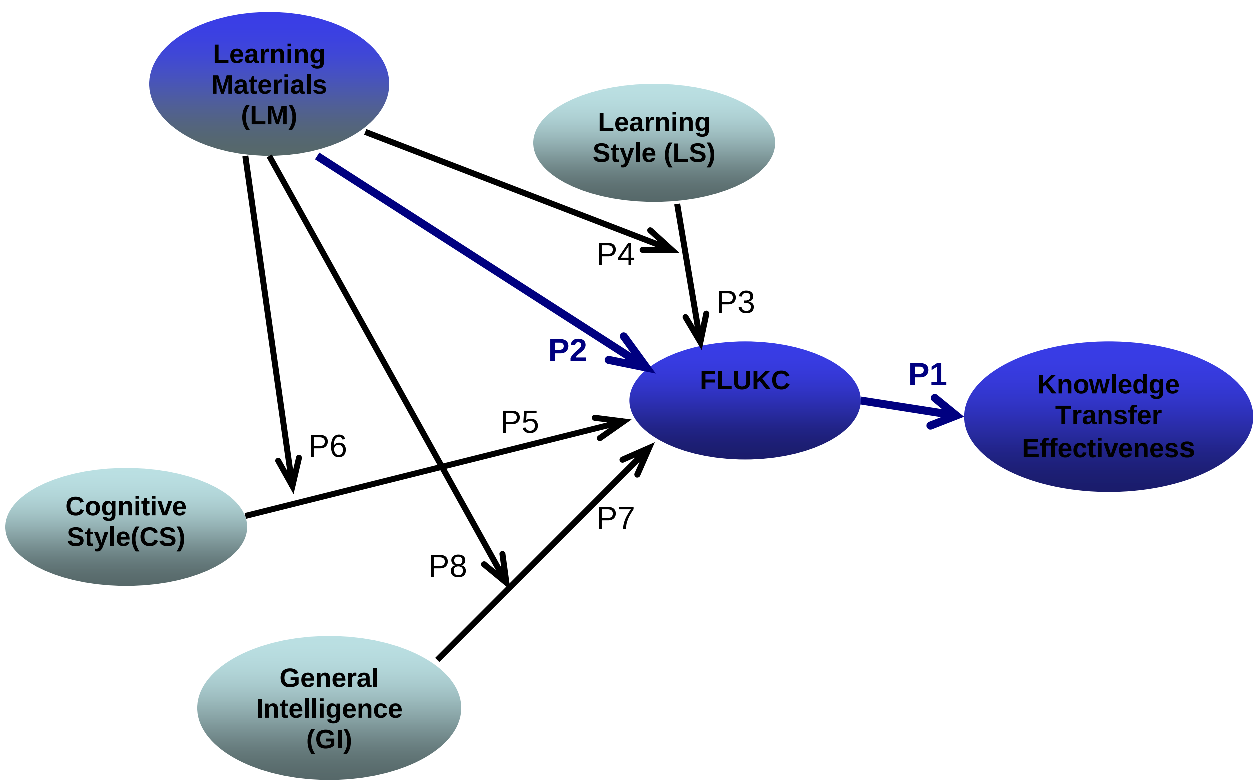


Figure 3-3. Conceptual Model of CF and Knowledge Transfer

adaptation of knowledge to new problem-solving situations. Hence, I posit that higher level of CF leads to better KT performance.

Proposition 1. A higher level of CF will lead to more effective KT.

The Cognitive Flexibility Theory (Spiro et al. 1987) sheds lights on how learning can be designed to develop CF. CFT points out that, characteristics of ill-structuredness found in most knowledge domains lead to serious obstacles to using instructed knowledge in new situations that differ from the conditions of initial instruction. A rich and flexible understanding of a complex knowledge domain requires full exploration from different intellectual perspectives. CFT considers CF a function of both the way knowledge is presented (e.g., along multiple rather than single conceptual dimensions) and the processes that operate on learners' mental models (e.g., processes of schema assembly rather than intact schema retrieval). These two dimensions are consistent with those of Kolb's ELT, which are grasping experience and transforming experience, respectively. Specifically, CFT provides the following principles for designing learning methods: (1) providing multiple representations of content; (2) supporting context-dependent knowledge and avoiding oversimplification of the content domain; (3) emphasizing knowledge construction and not the transmission of information; and (4) building interconnection among knowledge sources. I propose that learning methods that follow the CFT principles tend to lead to higher level of CF.

Proposition 2. CFT principles embodied learning methods will lead to higher level of CF than those that do not follow the CFT principles.

3.3.2 Learning Style Effects

Extant literature contends that an individual's learning style interacts with learning environment to systematically affect learning outcome (Bostrom et al. 1990; Kolb et al. 2005; Olfman et al. 2000). Bostrom et al.'s (1990) learning framework suggests that learning style both directly affects the formation of learners' mental models and has impacts through interacting with the learning process. Using Kolb's learning style theory, they postulated that individuals who are abstract conceptualizers have the ability or experience to discover the rules and structures inherent in a knowledge domain; while on the opposite end, the individuals who favor learning through concrete experience draw heavily on prior referent experiences. Kolb's learning style theory argues that people who favor the abstraction experience-grasping mode, including *Assimilators* and *Convergers*, favor working with abstract concepts and theories. Assimilators excel at understanding wide-ranging information and organizing it in a clear logical format, Convergers at best at finding solutions to practical issues with what they learn. I argue that CF requires good and deep understanding of concepts and the ability of abstract conceptualization, therefore, people who prefer the Abstract Conceptualization mode tend to develop high CF.

Proposition 3. Learners who prefer the Abstract Conceptualization mode of learning will develop higher CF when compared with learners who prefer the Concrete Experience mode of learning.

The previous relationships were proposed with an understanding that learning preference does not equate capability. As Bostrom et al. (1990, p.109) pointed out, "it is likely, but not necessary, that an individual's preferred method of learning implies that he/she will have a higher ability to perform in the mode of learning that he/she chooses."

I purport that learning methods that are designed following the principles of CFT show learners multiple perspectives, multiple representations of concepts and the interconnection between them. Therefore, people who are not predisposed to develop high level of CF can take advantage of the specially designed learning methods and improve their CF about the materials. Hence, I propose:

Proposition 4. When CFT principles embodied learning methods are used, the differences in CF between learners who prefer the Abstract Conceptualization mode of learning and learners who prefer the Concrete Experience mode of learning will be reduced.

3.3.3 Cognitive Style Effect

Kirton's Adaption-Innovation Theory (Kirton 1976) states that individuals tend to approach problems either by adaptation or by innovation. When confronted with a problem, a *habitual adaptors* turn to established procedures and comply with conventional rules, practices and perceptions of the group to which they belong, while *habitual innovators* attempt to approach the problem in a new light by restructuring the problem. I argue that because innovators habitually attempt to reorganize problems, they are not likely to be tied to single or fixed views. They tend to be more experienced in recognizing concepts represented in different problem contexts and seeing their interconnections. Moreover, they are predisposed to develop flexible rather than rigid views of things they learn. Therefore, innovators tend to develop higher CF in learning than adaptors who habitually respect established procedures.

Proposition 5. Habitual innovators on average develop higher levels of CF than habitual adaptors.

As CFT principles are intended to increase CF in learning in general, I argue that with the assistance of learning methods following the principles of CFT, the differences in CF as an outcome of learning between innovators and adaptors will decrease.

Proposition 6. When CFT principles embodied learning methods are used, the differences in CF between habitual innovators and habitual adaptors will be reduced.

3.3.4 General Intelligence Effect

As has been pointed out before, CF has been considered as a component of general intelligence (Carroll 1988), it is likely that for individuals with higher intelligence, the CF with respect to specific learning target as a learning outcome is also higher than the CF of those with lower intelligence. However, with the assistance of CF emphasizing learning methods, the difference between the learning outcomes of individuals with high and low general intelligence is expected to decrease.

Proposition 7. Individuals with high level general intelligence on average develop higher levels of CF than those with lower level general intelligence.

Proposition 8. When CFT principles embodied learning methods are used, the differences in CF between high level intelligence individuals and low level intelligence individuals will be reduced.

The conceptual model and propositions conclude this chapter. In the next chapter, the research method used to test this model is discussed.

Chapter 4: RESEARCH METHOD

Chapter 4 covers research method. Lab experiment was used to collect the data for model testing. The experimental setting, sample frame and subjects, treatment detail, experimental procedures are discussed. A review of constructs, their operationalization and measures, and the data analysis methods are summarized.

4.1 Lab Experiment Method

This study aimed to provide rigorous exploration of alternative means of knowledge presentation through the use of a laboratory experiment. A lab experiment (Creswell 2003) was designed and used. Experiments offer several advantages. First, the study may achieve high internal validity because of the high level controls the researcher has over the variances associated with the independent variables and those connected with extraneous variables. The variances of the independent variables are controlled for through manipulation in the experimental design. The variance of the extraneous variables can be controlled for in one the three ways: one, holding constant the extraneous variables in the experimental design; two, measuring the extraneous variables and statistically removing their effects in the analysis; and three, randomly assigning subjects to treatment and control groups. All three methods were applied to control the variances of the extraneous variables. By controlling for all other factors that might influence the outcome, the researcher can claim the impact of the treatment on the outcome. Second, the external validity is higher than case studies or observational studies because experiments consider more replications of the phenomenon under study. Third, experiments lend more power to discover the hypothesized relationship by giving the researcher more control over the variances of the independent variables.

Individual differences have been shown to have significant influences on learning outcome (Bostrom et al. 1990). In addition to the three cognitive traits included in the model, other individual non-treatment differences such as the subjects' experience about the knowledge content, the task, self-efficacy, motivation to learn, reading comprehension, gender, and age may influence the learning outcome. These potential influences were controlled for in two ways. First, influencing factors identified above were measured and used as covariates in the analysis. Second, random assignment was used to cancel out influences of non-treatment differences. The random assignment helps to equate the units in the treatment and control group in general (Cook et al. 1979). In principle, randomization controls for all unmeasured variables.

4.2 Subjects

Student subjects were used, who were future knowledge workers as well as current knowledge workers in their field of study. The sample for the experiment composed of the undergraduate students of a large public university in the southeast of the United States who were enrolled in an introductory MIS course in the Spring semester of 2007. All students enrolled in the class (708 in total) were included in the sample without discrimination. Participation was voluntary. One credit point was given to the participants as an incentive to take part in the experiment. Out of the 708 enrolled students, 252 signed up for the experiment. The subjects were randomly assigned to either the control condition group or the treatment condition group in the following way. All names of the subjects were listed in an Excel worksheet, the RAND() function in Excel was called to return a random number between 0 and 1 for each subject. The subjects whose number was greater or equal to 0.5 were assigned to the treatment group, while those whose number was less than 0.5 were assigned to the control group. As a result, 123 were randomly assigned to the control group, and 129 were assigned to the treatment group.

Of the 252 students who signed up, 2 dropped out of the study at the stage of the online survey, one from each group. The rest 250 students included 131 female students and 119 male students. Another 43 students dropped out at the experiment stage by not showing up for the experiment. Out of the 207 students who took part in the experiment, 97 were in the control group, and 110 were in the treatment group; 114 were female and 93 were male. Some students did not follow the instructions to complete the CF measuring step. For instance, 12 students used non-voting related concepts while the measurement procedure was to use voting related concepts exclusively. As a result, those data cannot be used. A total of 194 students had valid CF measures, with 88 in the control group and 106 in the treatment group, and 106 being female and 88 being male.

Beside invalid CF measures, missing data appeared in other two places, the online survey and the KT measures. Some subjects failed to answer all questions in the survey, which measured individual cognitive preferences and demographics, or the KT measures. Consequently, those records were not included in all analyses where the missing data were concerned. A total of 184 subjects had no missing data for all measures, and their data were used in the hypothesis testing. The numbers of data points collected are listed in Table 4-1.

Table 4-1. Number of Collected Data Points

Individual Characteristics					
Total	250				
		Control	128	Female	131
		Treatment	122	Male	119
KT Measures					
Total	207				

		Control	97	Female	114
		Treatment	110	Male	93
CF Measures					
Total	194				
		Control	88	Female	106
		Treatment	106	Male	88
All Valid Record					
Total	184				
		Control		Female	
		Treatment		Male	

4.3 Procedure

The subjects were assigned to one of 12 experiment sessions. One researcher conducted all 12 experiment sessions. The subjects were assigned to an experiment session of their choice. All sessions were completed in the same week. Each session was about one hour in length, starting at one of the following time points: 9:05AM, 12:35PM, 2:20PM, 4:05PM, or 5:00PM.

The steps of the experiment are listed in Table 4-2. Before coming to the experiment session, the subjects took an online survey which measured the individual's learning style, cognitive style, general intelligence, and demographics. The experiment was held in a classroom setting. Paper and pencil were used. The experiment had the following steps. First the subjects were given a brief introduction of the experiment procedure and asked to fill out a pre-learning questionnaire in which information about their pre-existing knowledge of the knowledge content was collected. Then the learning period started and the two groups were given their corresponding learning materials to read. When the subjects were done reading they were given the CF measurement booklet to fill out. The CF measurement booklet was collected before moving to the next step. Following the CF measurement was the factual knowledge test which consists of five multiple choice questions. The factual test booklet was collected before the subjects were given three problem-solving tasks (in the order of Task 3, Task 1, and Task 2) to do. During all this time, the subjects kept the learning materials and were free to make any reference to the materials. The last step was filling out a post-experiment questionnaire which asked the subjects' overall satisfaction of the learning process and their confidence about the answers for the problem-solving tasks.

Table 4-2. Experiment Procedure

Step	***Material***	***Purpose***	***Duration***
Online Survey	Learning Style (Kolb Learning Style Inventory Version 3.1), Cognitive Style (Kirton's Cognitive Style Inventory), Demographics (Appendix F)	Collect data of individual's learning style, cognitive style, GPA, SAT, and demographics.	Approximately 15 minutes.
Experiment Steps			
Consent Form	Consent Form (Appendix C)	Let the subjects get familiar with what to expect to happen in the experiment.	Approximately 1 minute
Pre-learning Questionnaire	Paper and pencil questionnaire (Appendix D)	Collect data about subjects' pre-existing knowledge of the knowledge content to be learned in the experiment.	Approximately 1.5 minute
Learning Period	Reading materials on paper (Appendix A)	Allow the subjects to learn the knowledge content by reading what was presented on paper.	Approximately 10 minutes
CF measurement	CF measurement booklet (Appendix B.2)	Measure the level of flexible understanding of the knowledge content.	Approximately 10 minutes

Factual Knowledge Test	Multiple choice questions (Appendix B.1)	Measure the level a subject masters the factual knowledge of the knowledge content, or the basics of AV and PV.	Approximately 1.5 minutes
KT Measurement	Problem solving tasks (Appendix B.3)	Measure subjects' performance of knowledge application.	Approximately 9 minutes
Post-experiment Questionnaire	Paper and pencil questionnaire (Appendix E)	Measure subjects' satisfaction with the learning process	Approximately 1 minute

4.4 Knowledge Content

The experiment involved learning some knowledge in a specific area, measuring how flexibly the subjects understand the concepts and relationships learned in the learning session, and testing the subjects' performance of applying what was learned in problem solving. The knowledge content used in the experiment was selected so that the impact of prior knowledge one had was minimum. Approval Voting (AV) was used as the knowledge content in the experiment for the following reasons. First, while the underlying rules of approval voting are extremely simple, the implications of AV for voting are wide, complex, and situation dependent. Therefore, it is rich on the tacit aspects of knowledge and thus makes a good ill-structured domain, which is the typical context of knowledge transfer. Second, the rules of AV are simple enough to be learned in the learning session, which fits into our experiment timeframe. Three, it was unlikely that the undergraduate experiment subjects had had much prior knowledge of AV, consequently, confounding effect was reduced as much as possible.

Approval Voting is a voting procedure for multi-candidate elections (i.e., elections with at least two candidates per seat) in which voters can vote for, or approve of, as many candidates as they like for each seat to be elected. Each candidate who is approved of receives one vote, and the candidate with the most votes wins (is elected for the seat). AV is different from Plurality Voting (PV) in that under the PV rule, each voter is allowed to vote for only one candidate per seat. Approval Voting is a voting system in which each voter can vote for as many or as few candidates as the voter chooses. Each voter may vote for as many options (or candidates) as he or she chooses, at most once per option (or candidate). This is equivalent to saying that each voter may "approve" or "disapprove" each option (or candidate) by voting or not voting for it. The votes for each option are tallied, for a single-seat election, the option (or candidate) with the most votes wins; for multiple-seat election, the options (or candidates) with the most votes win.

The theoretical and practical issues on this subject are rich, and can get very complicated. Given the time constraint of the experiment, the experiment materials focused on AV as a voting system alternative to the commonly used Plurality Voting system, and introduced the influences of AV on voting mostly by contrasting it with PV. The knowledge content consisted of two main aspects: one, the rule of AV; and two, the comparison of AV with PV with respect to selecting a candidate who has broad overall support. The two aspects were presented using two sets of reading materials, one set in abstract language as high level descriptions (see Abstract Presentation in Appendix A), and the other set in application cases (see Treatment Group Cases and Control Group Case in Appendix A).

4.5 Treatments

During the learning period of the experiment, the treatment group and control group were given reading materials that cover the knowledge content to be learned and used later to solve problems. The reading materials were designed to ensure two things: 1) that both control and treatment groups get the same knowledge content; and 2), that the knowledge presentation for the treatment group enhances flexible understanding. It is important to ensure that both the treatment and control groups get the same knowledge content. In operationalization, that was reflected by the abstract description of the AV rule and impacts (Abstract Presentation in Appendix A) that was identical to both groups. The abstract presentation of the knowledge covered both aspects of the knowledge content, namely, definitions of AV and discussions about some impacts of AV. The abstract presentation alone constituted the knowledge content, was in abstract language, and was provided to both the treatment and the control group indiscriminately.

A second set of materials that were different were given to the control and treatment group to operationalize the second point. Learning materials that fostered CF were created for the treatment group and which do not foster CF in particular were created for the control group. The Cognitive Flexibility Theory (CFT) (Spiro et al. 1987) provides four principles for designing learning materials to enhance flexible understanding one develops about the materials. These principles include: (1) providing multiple representations of content; (2) supporting context-dependent knowledge and avoiding oversimplification of the content domain; (3) emphasizing knowledge construction and not the transmission of information; and (4) building interconnection among knowledge sources.

CFT is a theory of case-based learning and asserts that effective learning is context-dependent. Context information is needed to understand the interdependencies associated with specialized knowledge (Carlile 2002). Acknowledging the situated and tacit characteristics of knowledge and their profound implications in KT (Brown et al. 1991; Cook et al. 1999), cases were used as the teaching material for both the treatment group and the control group to make the result as comparable as possible. Cases provide context-dependent knowledge, implementing CFT's principle 2. For the treatment group, CFT principles 1, 3, and 4, which are multiple representations of content, knowledge construction, and knowledge interconnection, were also applied. In other word, the treatment learning materials incorporated all four principles of CFT, and the control learning materials incorporated principle 2 only. A comparison of the treatment and control conditions is provided in Table 4-3 .

Table 4-3 Comparison of Treatment and Control Condition

CFT Principles	Treatment Condition	Control Condition
(1) multiple presentations of content	✓	
(2) context-dependent knowledge	✓	✓
(3) emphasis on knowledge construction, not transmission of information	✓	
(4) interconnection of knowledge sources	✓	

Multiple simple cases were used for the treatment group (referred to as multi-case treatment condition henceforward) and a single full case was used for the control group (referred to as full case control condition henceforward). The readability of these cases was comparable (see Table 4-4). The Flesch Reading Ease was 54.73 on average for the 3 treatment cases and 60.5 for the control case (second row from bottom in Table 4-4). The average Flesch-Kincaid Grade level was 10.13 on average for the 3 treatment cases and 10.2 for the control case (last row of Table 4-4).

The treatment condition and control condition incorporated CFT principles differently. The comparison of these conditions is discussed below in detail.

Table 4-4. Case Readability

	Treatment Case 1	*Treatment Case 2*	*Treatment Case 3*	***Treatment Case Average***	***Control Case***
Sentences per Paragraph	*5.2*	*5*	*4.2*	***4.8***	***4.1***
Words per Sentence	*16.9*	*20*	*18.8*	***18.57***	***21.8***
Character per Word	*4.4*	*4.8*	*4.6*	***4.6***	***4.2***
Passive Sentences	*4%*	*6%*	*19%*	***10%***	***12%***
Flesch Reading Ease	*65.8*	*49.5*	*48.9*	***54.73***	***60.5***
Flesch-Kincaid Grade Level	*8*	*11.3*	*11.1*	***10.13***	***10.2***

4.5.1 Features Common to both Conditions

CFT principle 2 (**Context-Dependent Knowledge**) was applied in the reading materials for both the treatment and control conditions. Principle 2 states that learning materials should not over simplify the content domain, rather, it should present context-dependent knowledge. Case presents knowledge content in context rather than in abstraction. Cases in the form of stories describe situations, within which the knowledge content is embedded, correspondingly, cases provide both the most specific and most cohesive (i.e., having the property of tying together several aspects of a situation) applicable knowledge (Kolodner et al. 1996).

While the abstract description explained the rule and impacts of AV in plain language, treatment and control cases presented the knowledge in context. The knowledge content covered in the abstract descriptions included the following points: (1) under AV, one can give the vote to all candidates that he/she approves for the seat to be elected; (2) under PV, one can give the vote to only one candidate per seat; (3) AV encourages sincere voting more than PV, because PV is susceptible to ‘strategic voting’, which refers to the situation when the 1st choice is a weak candidate (one who doesn’t have a good chance to win out), the voter often times gives the vote to a different candidate who is acceptable (but less favorite) and has a better chance to win; (4)

AV helps to select a candidate with broad support by considering voters' other choices in addition to the absolute 1st choice.

All knowledge points were addressed with context in each case. See the matrix of the cases and points made in each case in Table 4-5. Strategic voting was addressed explicitly in treatment case 1 by mentioning the term 'strategic voting' in the case context. In all other cases (treatment case 2 and 3 and the control case), strategic voting was relevant but was not addressed explicitly.

Table 4-5. Knowledge Points Covered in Learning Cases

Knowledge Point	***(1) AV Rule***	***(2) PV Rule***	***(3) Strategic Voting***	***(4) Broad Support Winner***
Treatment Case 1	✓	✓	*directly*	✓
Treatment Case 2	✓	✓	*indirectly*	✓
Treatment Case 3	✓	✓	*indirectly*	✓
Control Case	✓	✓	*indirectly*	✓

4.5.2 Special Features for the Treatment Condition

In addition to the second design principle of CFT, the treatment condition incorporated the other three principles by using multiple cases.

Multiple Presentations of Content (Principle 1) The multi-case treatment condition incorporated principle 1 of CFT. In particular, 3 cases were used for the treatment group. In each case, components of the knowledge content are embodied in a different context; together, the cases provide multiple representations of the knowledge content.

Emphasis of Knowledge Construction (Principle 3) The multiple-case design also incorporated principle 3. According to Case-Based Reasoning (CBR) theory (Kolodner 1997), learning is done by extending one's knowledge by incorporating new experiences into memory, by re-indexing old experiences to make them more accessible, and by abstracting out generalizations from experiences. Two sets of procedures occur in this learning process: one, those that operate when cases are encoded and inserted into memory; and two, those that operate at retrieval time. At insertion time, a learner interprets the situation and identifies some lessons and the situations when these lessons can be applied. At retrieval time, a learner uses the current goals and understanding of the current situation to probe into memory, looking for old situations that can be re-applied. The multi-case treatment condition supported the process of knowledge reconstruction. When a subject read a case, knowledge components were encoded and inserted into memory for future reference. As new cases were presented, previously encoded components could be retrieved, compared, and integrated to incorporate new information and experiences. Therefore, the multi-case condition provided multiple opportunities for insertion, retrieval, interpretation, comparison, and incorporation. In this process, knowledge could be actively constructed and re-constructed rather than taken as intact parts and stored into memory.

In addition, CBR gives failure a central role in promoting learning. Failure at applying an old case in a new situation triggers explanation that might result in reinterpreting (reindexing) old situations and/or discovering new kinds of interpretations (indexes) (Kolodner et al. 1996). Treatment Case 3 was designed to conflict the assumption that a learner might have had based on the learning materials prior to that point. Particularly, prior learning materials (the abstract description and Treatment Case 1 and 2) had introduced AV in comparison to PV in terms of rules and outcomes. The subjects might have developed an impression that AV and PV tend to give different election outcome. However, in treatment Case 3, AV and PV outcomes agreed on the same winner of the election. This feature was included to foster knowledge construction.

Interconnection of Knowledge Sources (Principle 4) One comment was made at the end of each case to relate the case to a point in the abstract presentation explicitly. In addition, questions were asked at the end of each case to relate the case to other points in the abstract presentation. Although the relationship was not made explicit, the learners were encouraged to make that connection on their own. By doing this, it was expected that the learners would not only connect each case to the specific point discussed in the explicit comment, but also connect the case to the knowledge points expressed in the abstract description. Furthermore, it was expected that the learners would synthesize the knowledge presented in the cases by seeing how the knowledge points were reflected in different contexts. Specifically, questions in treatment Case 1 related to knowledge points (1), (2), and (3), or AV rule, PV rule, and strategic voting. Questions in treatment Case 2 related to knowledge points (1), (2), and (4), or AV rule, PV rule, and broad support winner. Questions in treatment Case 3 related to knowledge points (1), (2), and (4).

4.6 Variables and Measures

Figure 4-1 provides an overview of the variables in the study and their operationalization in the experiment. Table 4-6 lists the measures that were obtained in the experiment, although not all were used in the analysis.

4.6.1 Independent Variables

Independent variables in the analysis included knowledge presentation (the treatment condition), learning style, and cognitive style. The treatment condition has been discussed earlier in this chapter. In this subsection, the other two independent variables, learning style and cognitive style, will be discussed.

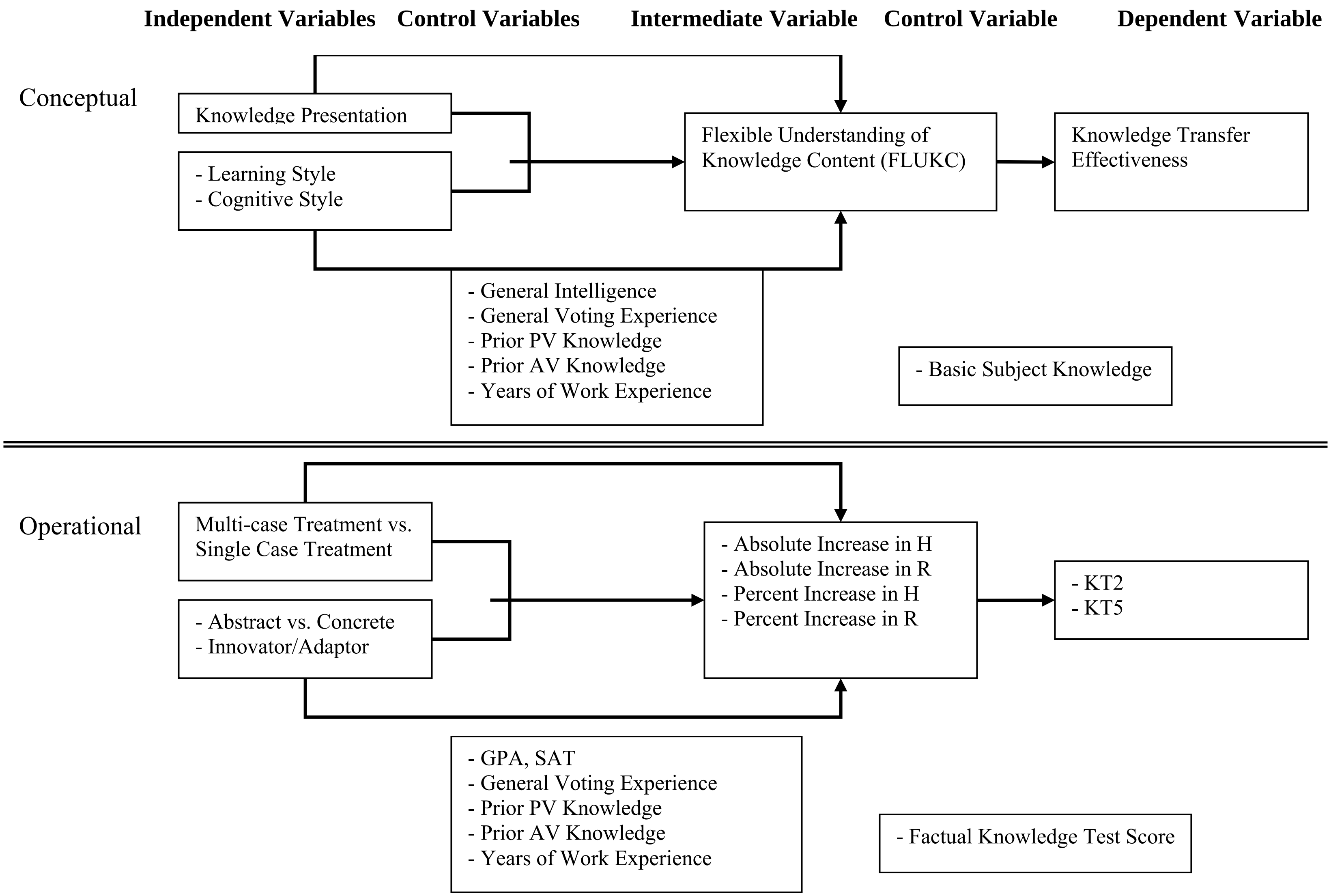


Figure 4-1. Research Model and Variables

Table 4-6. Variable List

Independent Variable			
Variable Name	***Description***	***Measure***	***Scale***
T/C(1=T)	*Multi-case Treatment vs. Single Case Treatment*	*0 for Control Condition (Appendix A.3); 1 for Treatment Condition (Appendix A.2)*	*Nominal (T=1; C=0)*
CogStyle	*Cognitive Style Continuous Measure*	*Kirton's Cognitive Style Inventory*	*Interval*
CogStyleCategory	*Cognitive Style Category Binary Measure*	*Kirton's Cognitive Style Inventory, Section 4.6.1*	*Nominal (Innovator=1; Adaptor = 0)*
AC	*Learning Mode – Abstract Conceptualization*	*Kolb Learning Style Inventory Version 3.1*	*Interval*
AE	*Learning Mode – Active Experimentation*	*Kolb Learning Style Inventory Version 3.1*	*Interval*
CE	*Learning Mode – Concrete Experience*	*Kolb Learning Style Inventory Version 3.1*	*Interval*
RO	*Learning Mode – Reflective Observation*	*Kolb Learning Style Inventory Version 3.1*	*Interval*
AE-RO	*Preference on the Processing Continuum of Learning Mode*	*Kolb Learning Style Inventory Version 3.1*	*Interval*
AC-CE	*Preference on the Perception Continuum of Learning Mode*	*Kolb Learning Style Inventory Version 3.1*	*Interval*
AbstractLevel	*Three-level Categorical Measure of the AC-CE Dimension*	*Section 4.6.1*	*Ordinal (Concrete = -1, Medium = 0, Abstract = 1)*
AbstThk2Level	*Two-level Categorical Measure of the AC-CE Dimension*	*Section 5.3*	*Ordinal (Concrete = 0, Abstract = 1)*
FLUKC Measures			
Variable Name	***Description***	***Measure***	***Scale***
H1	*Complexity of Initial Grouping*	*Appendix B.2, Section 4.6.2*	*Ratio*
R1	*Standardized H1*	*Appendix B.2, Section 4.6.2*	*Ratio*
H2	*Complexity of the 2^{nd} Grouping*	*Appendix B.2, Section 4.6.2*	*Ratio*
R2	*Standardized H2*	*Appendix B.2, Section 4.6.2*	*Ratio*
CFdiffH	*Difference between Complexity (H2-H1)*	*Section 4.6.2*	*Ratio*
CFdiffR	*Difference between Standard Complexity (R2-R1)*	*Section 4.6.2*	*Ratio*

CFRH	*Percent Increase in Complexity*	*Section 4.6.2*	*Ratio*
CFRR	*Percent Increase in Standard Complexity*	*Section 4.6.2*	*Ratio*
NoOfGroup_1	*Number of Groups in Initial Grouping*	*Appendix B.2, Section 4.6.2*	*Interval*
gr_combi_1	*Number of Group Combination in Initial Grouping*	*Appendix B.2, Section 4.6.2*	*Interval*
NoOfGroup_2	*Number of Groups in 2nd Grouping*	*Appendix B.2, Section 4.6.2*	*Interval*
gr_combi_2	*Number of Group Combination in 2nd Grouping*	*Appendix B.2, Section 4.6.2*	*Interval*
Control Variable			
Variable Name	***Description***	***Measure***	***Scale***
GPA	*GPA at UGA*	*Appendix F Question 7*	*Interval*
SAT	*SAT Score*	*Appendix F Question 8*	*Interval*
YrsWrkExp	*Years of Work Experience*	*Appendix F Question 3*	*Ordinal*
Gender(0=F, 1=M)	*Gender*	*Appendix F Question 6*	*Nominal*
USCitizen(1=Yes)	*U.S. Citizenship*	*Appendix D Question 1,2*	*Nominal*
VoteGeneral	*General Voting Experience*	*Appendix D Question 3,4,5,6*	*Ordinal*
PVknowledge	*Prior PV Knowledge*	*Appendix D Question 7, 8*	*Ordinal*
AVKnowledge	*Prior AV Knowledge*	*Appendix D Question 9, 10*	*Ordinal*
Session	*Experiment Session*	*See subsection 4.6.5*	*Nominal*
SessionCode	*Experiment Session Category*	*See subsection 4.6.5*	*Nominal*
ClassCode	*Class Section*	*See subsection 4.6.5*	*Nominal*
Dependent Variable			
Variable Name	***Description***	***Measure***	***Scale***
Factual Knowledge (FacK)	*Score on the Factual Knowledge Test*	*Appendix B.1 (Total of five questions)*	*Interval (0 to 5)*
Task1.15	*Score on Problem Solving Task1.15*	*Appendix B.3 Task1 Question 15*	*Interval (0,1)*
Task1.16	*Score on Problem Solving Task1.16*	*Appendix B.3 Task1 Question 16*	*Interval (0,1)*
Tas2.17	*Score on Problem Solving Task2.17*	*Appendix B.3 Task2 Question 17*	*Interval (0,1)*
Task2.18	*Score on Problem Solving Task2.18*	*Appendix B.3 Task2 Question 18*	*Interval (0,1)*

Task2.19	*Score on Problem Solving Task2.19*	*Appendix B.3 Task2 Question 19*	*Interval (0,1)*
Task2.20	*Score on Problem Solving Task2.20*	*Appendix B.3 Task2 Question 20*	*Interval (0,1)*
Task3.S1	*Score on Problem Solving Task3.S1*	*Appendix B.3 Task3 Scenario 1*	*Interval (0,1,2)*
Task3.S2	*Score on Problem Solving Task3.S2*	*Appendix B.3 Task3 Scenario 2*	*Interval (0,1,2)*
KT2	*The Sum of Task3.S1 and Task3.S2*	*(See left)*	*Interval (0 to 4)*
KT5	*The Sum of Task1.16, Task2.18, Task2.20, Task3.S1, and Task3.S2*	*(See left)*	*Interval (0 to 7)*
Post-test Check			
Variable Name	***Description***	***Measure***	***Scale***
SatLearningProcess	*Satisfaction with the Learning Process*	*Appendix E Question 1*	*Interval*
ContextSuff	*Satisfaction with the Sufficiency of the Context in Learning Case(s)*	*Appendix E Question 2*	*Interval*
ConfidenceOfAnswer	*Confidence about Answers to Problem Solving Tasks*	*Appendix E Question 3*	*Interval*
SelfEval	*Self-evaluation of AV Knowledge*	*Appendix E Question 4*	*Interval*

Learning Style

The Kolb Learning Style Inventory (LSI) (Version 3.1) was administered to measure learning preference. Kolb's Experiential Learning Theory (ELT) (Kolb 1984; Kolb et al. 1975) conceptualizes four learning modes in the learning process, abstract conceptualization (AC), concrete experience (CE), reflective observation (RO), and active experimentation (AE). For each dimension a single score is calculated (with 12 preference ranking questions) which indicates how much one relies on that learning modes. Each score is in the range of 12-48. The four scores add up to a total of 120. The ranking method causes the four dimensions to be dependent. Thus, a high score on one necessitates a lower score on others.

The four dimensions score are used to compute two additional scores, namely, the relative degree of abstractness or concreteness (AC-CE), and the relative degree of activeness or reflectiveness

(AE-RO). The coding of learning style focused on the level of abstract conceptualizing as the research model hypothesized a positive relationship between abstract conceptualizing and flexible understanding. In Kolb's Learning Style Inventory (Version 3.1), the level of abstract conceptualizing is measured by the relative preference of Abstract Conceptualization as apposed to Concrete Experience (AC-CE). AC-CE represents an individual's preference for abstractness or concreteness. The sample mean of relative abstractness (AC-CE) for the treatment group and control group is 7.3 and 5.11, respectively. The sample mean of relative activeness (AE-RO) for treatment and control group is 8.03 and 9.74, respectively. Both measures are pretty close to the center of the learning style grid, which locates at the intersection of roughly 6.95 on the AC-CE scale and 6.20 on the AE-RO scale, which means that generally speaking, the sample learning style is balanced rather than dominated by any particular learning mode.

Abstractness Level

On the AC-CE dimension, numbers greater than 12 represent learning style that favors the Abstract Conceptualization mode of learning, numbers smaller than 2 represent learning style that favors the Concrete Experience mode of learning (see Figure 4-2).

Based on this scale (Table 4-7), the continuous learning style measure AC-CE was converted into a three-level categorical variable Abstractness Level for the MANCOVA analysis.

Table 4-7. Abstractness Level Conversion Scheme

AC-CE Measure	***Abstractness Level***
Lowest thru 1	*-1 (Concrete)*
2 thru 12	*0 (Medium)*
13 thru Highest	*1 (Abstract)*

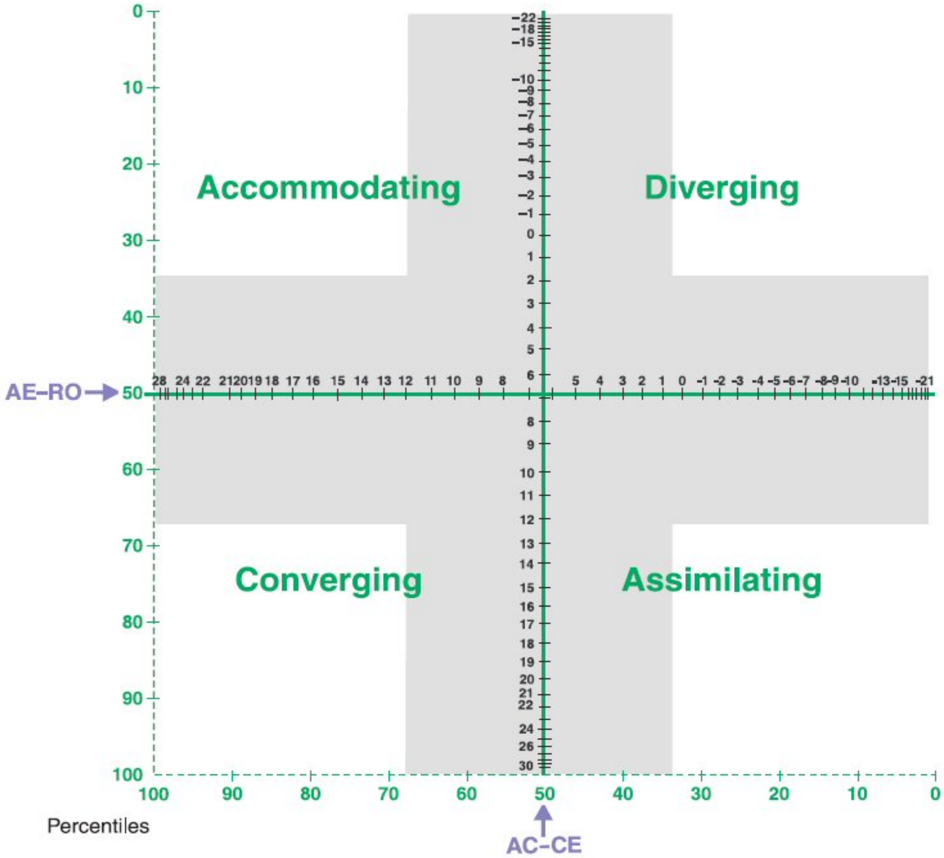


Figure 4-2. Kolb's Learning Style

AC represents an individual's level of preference for the abstract conceptualizing learning mode. The following frequency table (Table 4-8) describes the percentage of the subjects in each of the three categories.

Table 4-8. Frequency – Abstractness Level

Abstractness Level	Frequency	Percent
-1 (Concrete)	71	37.0
0 (Medium)	60	31.3
1 (Abstract)	61	31.8
Total	192	100.0

About one third of all subjects (n = 194) were in each of the three Abstractness Level categories, there were slightly more concrete learners (36.6%) than people in the medium range (36.6%) and abstract range (31.4%). The splits of these three groups were similar in the treatment group and control group. See Table 4-9. The Crosstabs analysis in Table 4-9 showed no significant difference in the distribution of Abstractness Level in the control group and treatment group (Pearson Chi-Square = 2.456, df = 2, p = 0.293, n = 194).

Table 4-9. Frequency – Abstractness Level by Condition Group

Abstractness Level	Total		Treatment Group		Control Group	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
-1 (Concrete)	71	36.6%	38	35.8%	33	37.5%
0 (Medium)	62	32.0%	30	28.3%	32	36.4%
1 (Abstract)	61	31.4%	38	35.8%	23	26.1%
Total	194	100.0	106	100.0	88	100.0

Cognitive Style

The original cognitive style inventory was measured with a 32-question inventory with each question assessing the individual's problem solving preference. Each question was answered on a 5-point Likert scale. The sum of the 32 values was a continuous scale with 32 at the low end, 160 at the high end, and a middle point around 96. Lower numbers represent more adaptive cognitive styles and higher numbers represent more innovative cognitive styles. The U.S. general population has an average of 94~95 on the scale. The majority (67%) fall in the middle range between 70 and 115.

To make the instrument more similar to a continuous scale, and therefore tapping extreme values better, a 7-level Likert scale, rather than a 5-level scale, was used and the numbers were converted to numbers on a 5-level scale to make them comparable to the original instrument. The following scheme to convert the numbers on a 7-level scale to a 5-level scale was used in calculation. Some items in the instrument are in reverse order (low number actually represents more innovative) and were converted to the corresponding number in calculation. For instance, if a person's answer is 2 or 3 for a regular question on the 7-level scale, then 2 is used in the calculation of the total score of his cognitive style. If, a person's answer is 2 or 3 for a reverse question on the 7-level scale, then 4 is used in the calculation of the total score of his cognitive style. See Table 4-10.

Table 4-10. Cognitive Style Coding Scheme

Regular Question	
7-level numbers	*5-level numbers*
1	*1*
2, 3	*2*
4	*3*
5, 6	*4*
7	*5*
Reversed Question	
1	*5*
2, 3	*4*
4	*3*
5, 6	*2*
7	*1*

The sample mean of Cognitive Style (CogStyle in Table 4-11) was 94.50 for a total of 194 subjects, 93.72 for the treatment group, and 95.25 control group. These means are in the same range as that of the general population of the U.S. and U.K. (which is 94~95). It also fell into the middle range of the scale (around the point of 96). The measure of cognitive style has moderate reliability, the Cronbach's Alpha of the 32 items in the inventory is 0.81. The values of cognitive style follow a normal distribution (see Figure 4-3).

Table 4-11. Cognitive Style Group Means

T/C(1=T)	N	Mean	Std. Error Mean	Std. Deviation	Min	Max
1	106	93.92	1.138	11.715	69	125
0	88	95.20	1.119	10.499	65	122
Total	194	94.50	0.802	11.170	65	125

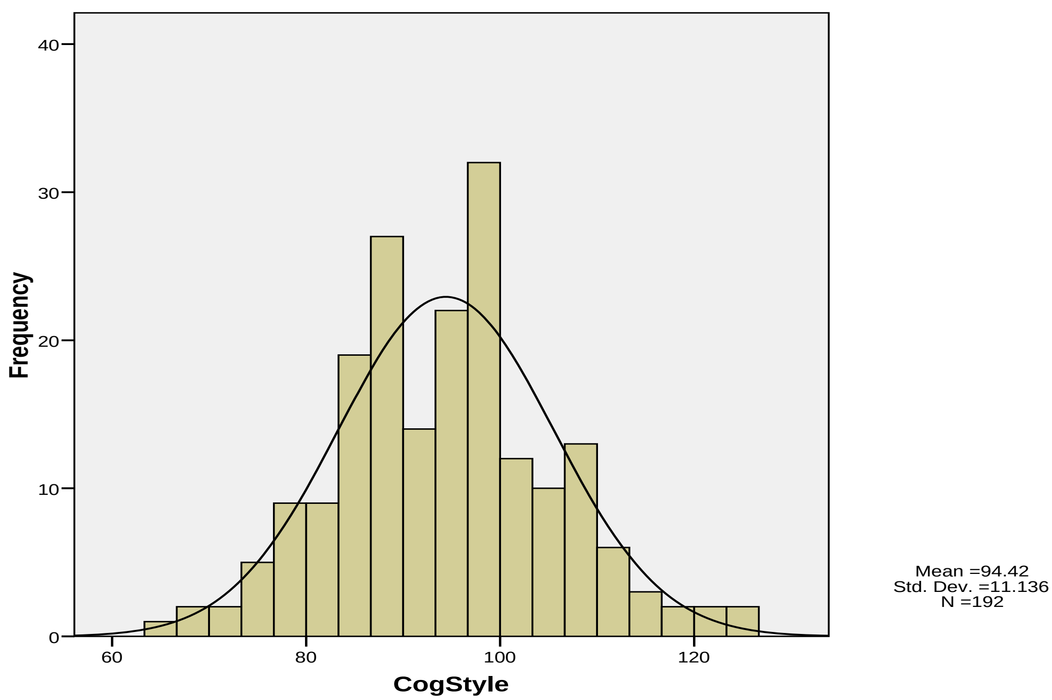


Figure 4-3. Distribution of Cognitive Style

Cognitive Style Category

To carry out MANCOVA analysis, a categorical measure Cognitive Style Category was generated from the continuous scale Cognitive Style using the converting scheme in Table 4-12.

The continuous cognitive style scale was spit into two halves at the midpoint around 96. The lower half represented habitual adaptors who prefer to stick close to established rules in problem-solving, the higher half represented habitual innovators who prefer to jump out of the box and create new solutions.

Table 4-12. Cognitive Style Conversion Scheme

Cognitive Style	***Cognitive Style Category***
Lowest thru 96	*0*
97 thru Highest	*1*

About 57% of all subjects fell in the adapter category, and 42% in the innovator category. The splits of these two groups were similar in the treatment group and control group. See Table 4-13. Crosstabs analysis showed no significant difference in the distribution of Cognitive Style Category in the control group and treatment group (Pearson Chi-Square = 0.036, df = 1, p = 0.85, n = 194).

Table 4-13. Frequency – Cognitive Style Category

Cognitive Style Category	**Total**		**Treatment Group**		**Control Group**	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
0 (Adaptor)	111	57.2%	60	56.6%	51	58.0%
1 (Innovator)	83	42.8%	46	43.4%	37	42.0%
Total	194	100.0%	106	100.0%	88	100.0%

Due to missing values in control variables (for instance, the SAT score), not all 194 subjects' data were included in the final analysis. There were a total of 184 subjects included in hypotheses testing. The numbers of subjects by individual characteristics and group belonging are displayed in Table 4-14.

Table 4-14 Number of Subjects by Condition in Analysis

Condition		By Condition	
Control	84		
Treatment	100		
Learning Style		**Control**	**Treatment**
Concrete	69	31 (36.9%)	38 (38.0%)
Medium	58	31 (36.9%)	27 (27.0%)
Abstract	57	22 (26.2%)	35 (35.0%)
Cognitive Style			
Adaptor	108	49 (58.3%)	59 (59.0%)
Innovator	76	35 (41.7%)	41 (41.0%)

4.6.2 Flexible Understanding of the Knowledge Content

Cognitive flexibility with respect to specific topic was defined as "the readiness with which the person's concept system changes selectively in response to appropriate environmental stimuli" (Scott 1962, p. 405). Flexible understanding of the knowledge content (FLUKC) was accessed using the two-step method introduced in Scott (1962). In the first step, the subjects were asked to list voting related concepts and group them. In the second step, the subjects were given new information and asked to regroup all concepts. Based on the grouping in the two steps, change-based measures of FLUKC were calculated. The procedure is explained in detail with examples in this subsection.

FLUKC Measurement Step One

The first step involved the subjects listing concepts of voting and grouping them according to the his/her understanding of the subsystems existing in the voting system. For instance, a subject may include 'voter', 'voting rule', 'candidate' in a group that represents the elements of an election, and include 'candidate', 'party', 'support rate' in another group that is related to campaign. Notice that the groups may overlap on some concepts, for instance 'candidate' appears in both groups in this example. Absolute complexity (H) and relative complexity (R) were computed based on the list and categories. H is the measure of dispersion, a measure borrowed from information theory (Attneave 1959). The following example illustrates how the complexity measure H and R were calculated. For instance, a subject listed concepts A, B, C, D, and E and grouped them into three groups: I (A, B, C), II (B, C, D), and III (A, D, E), with the concepts in groups included in parentheses. Concept-wise, A appears in I, III, B in I, II, C in I, II, D in II, III, E in III. Therefore, there are group combinations: I and III which has one member (A), I and II, which has two members (BC), II, III which has one member (D), and III which has one member (E). See parameters in Table 4-15:

Table 4-15. Grouping Example

Concept	***A***	***B***	***C***	***D***	***E***
Group I	✔	✔	✔		
Group II		✔	✔	✔	
Group III	✔			✔	✔
Group Combination	***I, III***	***I, II***	***I, II***	***II,III***	***III***
# of Concept in Group Combination	*1*	*2*	-	*1*	*1*

A measure of complexity (H) is calculated with formula $H = \sum p_i \log_2 \frac{1}{p_i}$, where $p_i = n_i/n$, n is the total number of concepts, and n_i is the number of concepts that appear in a particular combination of groups. As H tends to be inflated with the increase of the total number of concept n, the adjusted complexity R is calculated as $H/\log_2 n$. In the example above, H = 1.9219, R = 0.8277 (see calculations in Table 4-16 below).

Table 4-16. Calculation of H and R

Group Combination	***I, III***	***I, II***	***II,III***	***III***	***Total***
n_i	*1*	*2*	*1*	*1*	***5***
$p_i = n_i/n$, where n=5	*0.2*	*0.4*	*0.2*	*0.2*	-
$p_i \log_2 \frac{1}{p_i}$	*0.4644*	*0.5288*	*0.4644*	*0.4644*	***1.9219***
$H = \sum p_i \log_2 \frac{1}{p_i}$					***1.9219***
$R = H/\log_2 n$					***0.8277***

FLUKC Measurement Step Two

In the second step of Then the subjects were presented a list of 20 voting concepts which the researcher prepared. The concepts were chosen so that all concepts were covered in both the treatment and control group learning materials. It was unlikely that any list that the subjects came up with in the first step included all 20 concepts in the researcher's list. A subsequent inspection confirmed that in all cases, the researcher's list was different from the list generated by the subject to certain degree. Therefore, the researcher's list provided some new information to all subjects. The subjects were asked the following questions together with the researcher's list:

1. Are there any relevant concepts that appear in the list given to you but not in your original list? What are they?

2. Are there any concepts that are NOT in the list given to you nor in your original list, and you would add to your list? What are they?

3. Given the newly identified concepts in step 1 and 2, update your original list with the newly identified included. Would you modify your original grouping? If yes, regroup the concepts in the way that makes more sense to you.

H and R were calculated based on a subject's regrouping in the second step. The descriptive statistics of the Hs and Rs are listed in

Table 4-17

Table 4-17. Descriptive Statistics – FLUKC Measures

	N	*Range*	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
H1	*192*	*3.5219*	*0*	*3.5219*	*2.0830*	*0.6031*
R1	*192*	*1*	*0*	*1*	*0.6030*	*0.1528*
H2	*192*	*2.7709*	*1*	*3.7709*	*2.4186*	*0.6360*
R2	*192*	*0.7613*	*0.2387*	*1*	*0.5584*	*0.1454*

Four change-based measures (CFdiffH, CFdiffR, CFRH, and CFRR) of FLUKC were calculated based on the Hs and Rs – the absolute complexity measure and the weighted complexity measure. CFdiffH was the difference between H2 and H1. CFdiffR was the difference between R2 and R1. CFRH was the difference between H2 and H1 relative to H1. CFRR was the difference between R2 and R1 relative to R1. Note that the change of H may be positive or negative. No change in grouping was associated with low level of CF because it was assumed to reflect that one lacked the ability to modify the original grouping as he/she rigidly adhered to his/her initial concept system. The scales of these measures are listed in Table 4-18.

Table 4-18. FLUKC Measures

Variable Name	***Description***	***Scale***
H1	*Complexity of Initial Grouping*	**Continuous**
R1	*Weighted H1*	**Continuous**
H2	*Complexity of the 2nd Grouping*	**Continuous**
R2	*Weighted H2*	**Continuous**
CFdiffH	*Difference between Complexity (H2-H1)*	**Continuous**

CFdiffR	*Difference between Standard Complexity (R2-R1)*	**Continuous**
CFRH	*Percent Increase in Complexity*	**Continuous**
CFRR	*Percent Increase in Standard Complexity*	**Continuous**

As measures of FLUKC, the four variables have relatively high reliability (Cronbach's alpha = .85). It is appropriate to group them together in MANCOVA (Multiple Analysis of Covariance analysis). The descriptive statistics of these four variables are as listed below:

Table 4-19. Descriptive Statistics of CF Measures

Variable	*n*	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*	*Skewness*	*Z (skewness)*	*Kurtosis*	*Z (kurtosis)*
CFdiffH	*194*	*-2.20*	*1.99*	*0.34*	*0.63*	*-0.25*	*-1.45*	*1.04*	**2.99**
CFdiffR	*194*	*-0.50*	*0.52*	*-0.04*	*0.15*	*0.24*	*1.36*	*1.21*	3.49
CFRH1	*193*	*-0.63*	*1.59*	*0.22*	*0.36*	*0.91*	***5.20***	*1.62*	4.65
CFRR1	*193*	*-0.60*	*1.07*	*-0.04*	*0.27*	*1.08*	***6.20***	*2.37*	6.80

The Z scores showed that there are data points in CFdiffR, CFRH1, and CFRR1 that are more than two standard deviations away from the mean. They are potential outliers. Not knowing if they belong to the population intended for the study, all data were kept in the analysis. The Z score of skewness and kurtosis indicate that CFdiffR, CFRH1, and CFRR1 may not be normally distributed as the Z-scores are larger than 3.29, which is the threshold value for large sample (200 or more). This may render parametric tests such as MANCOVA inappropriate.

The test of normality shows that the Kolmogorov-Smirnov statistic for CFRH1 and CFRR1 are highly significant (Sig. less than .001), indicating that the two variables do not follow a normal distribution. As univariate normal distribution is a necessary condition for multivariate normality, the multivariate normality assumption of MANCOVA is violated. However, MANOVA is robust in the face of most violations of this assumption if the sample size is not small (e.g., < 20) (Field, 2005). The sample size is 184 after excluding records with missing values, therefore, MANCOVA was used to test the relationship.

4.6.3 KT Effectiveness

Problem-solving tasks were relied on to test subjects' effectiveness of KT. To test the conceptual model, it was necessary to measure the learners' capability to reorganize the knowledge learned to create solutions in situations that require the same knowledge but not in exactly the same way. In other words, the learners would need to "transfer" the knowledge learned according to situational demands. For instance, the learning materials exposed the learners to one-seat, multi-candidate situations (where exactly one winner is picked out of multiple candidates). Task 3 (Appendix B.3) involved multi-seat, multi-candidate election, where a council is to be selected out of multiple candidates. Task 1 and 3 requested the subjects to apply the knowledge learned strategically under AV, which was not discussed in the learning materials. The quality of solutions to the problem-solving tasks was used as the primary assessment of KT effectiveness. Time to complete the tasks was not used in the analysis as there was no significant difference in the time of the treatment group and the control group. Tasks used in the experiment are attached in Appendix B.3.

Three problem-solving tasks were used in the experiment. Task 1 had two questions, the first (Task1.15) was a straightforward application of the rule of AV rule (under specific voting condition, who wins); the second question (Task1.16) was an application of strategic voting. Task 2 had four questions. Question 1 (Task2.17) was a straightforward application of the rule of PV (under specific voting condition, who wins); Question 2 (Task2.18) asked whether PV satisfies the Majority Criteria (a new concept not mentioned in the learning materials) in the scenario of Task 2; Question 3 (Task2.19) was a straightforward application of the rule of AV (under specific voting condition, who wins); Question 4 (Task2.20) asked, whether AV satisfies the Majority Criteria in the scenario of Task 2. Task 3 had two questions (Task3.S1 and Task3.S2) about the application of AV knowledge in the context of multi-seat election.

Therefore the questions fell into two categories: those that were straightforward test of the factual knowledge about AV and PV, and those that required knowledge application. The five questions on the Factual Knowledge Test (see Appendix B.1), Task 1 Question 15, Task 2 Question 17, and Task 2 Question 19 were test of straightforward application of factual knowledge about AV, and Task 1 Question 16, Task 2 Questions 18 and 20, Task 3 S1 and Task 3 S2 were tests of knowledge application. The application tests were used in the analysis as measures of KT effectiveness.

Question Type	**Fact**	**Application**
Tasks	Factual Test Task1.15 Task2.17 Task2.19	Tasl1.16 Task2.18 Task2.20 Task3.S1 Task3.S2

Most students did well on the factual knowledge test. There were five multiple choice questions on the test, maximum score is 5. The average score of 192 subjects on the test is 4.54. The reliability of the five items is 0.858. The minimum and maximum score of Task1.16, Task2.18, Task2.20 was 0 and 1, respectively, the average of the three measures was 0.65, 0.71, 0.48, respectively. The minimum and maximum score of Task3.S1 and Task3.S2 was 0 and 2, respectively, the average of these two measures was 1.38 and 1.80, respectively. The descriptive numbers are in Table 4-20.

Table 4-20. Descriptive Statistics – Task Performance

	N	Minimum	Maximum	Mean	Std. Deviation
Factual	192	0	5	4.54	1.193
Task1.15	192	0	1	.81	.395
Tas2.17	192	0	1	.80	.403
Task2.19	192	0	1	.87	.337
Task1.16	192	0	1	.65	.478
Task2.18	192	0	1	.71	.453
Task2.20	192	0	1	.48	.501
Task3.S1	189	0	2	1.38	.679
Task3.S2	189	0	2	1.80	.545
Valid N (listwise)	189				

Task 3 is one of the problem-solving tasks used to measure the subject's performance of knowledge transfer. The task had two scenarios. To assess the performance on this task, a scheme was developed to match the answers to a numerical score based on how much thinking was involved in solving the task and how correct the thinking was. The score or scheme is listed in Table 4-21.

Table 4-21. Coding Scheme

Scenario	Answer	Score
Scenario 1.	D	2
	CDFG	2
	DG	1
	Other	0
Scenario 2.	D	2
	CDF	2
	CD	1
	DF	1
	Other	0

4.6.4 Control Variables

Six control variables were included when testing the relationship between the independent variables and FLUKC. They were GPA and SAT scores, work experience, prior PV knowledge, prior AV knowledge, and prior general voting experience. The GPA and SAT scores were surrogate measures for general intelligence, which has been found to have significant influences on learning and cognition. Voting related experience and knowledge were directly related to the study and should be controlled for in the analysis. Work experience was controlled for as work experience might help develop the ability of learning and problem-solving, and thus have a confound effect in the analysis.

When testing the link between FLUKC and KT Effectiveness, subjects' knowledge about the knowledge content might have confounding effect. KT requires a sound understanding of the subject matter. In other words, to be able to apply some knowledge to a new situation, a good grasp of that knowledge is necessary in the first place. The Factual Knowledge Test tested subjects' basic understanding of Approval Voting and Plurality Voting, and was used as a covariate in the regression analysis.

The means of the control variables in the control group and treatment group were compared. ANOVA analysis showed no significant differences in the control variables between the control and treatment groups. This indicates that there were no systematic differences between the two groups. The means of the six control variables by treatment condition are listed in Table 4-22.

Table 4-22. Control Variable by Treatment Condition

Variables	T/C	Std. Error	N	Mean	Std. Deviation	Min	Max
GPA	Control	0.04	86	3.34	0.41	2	4
	Treatment	0.04	106	3.27	0.40	1.93	4
	Total	0.03	192	3.30	0.41	1.93	4
SAT	Control	13.05	86	1232.43	120.99	924	1520
	Treatment	11.92	101	1237.15	119.77	930	1520
	Total	8.78	187	1234.98	120.03	924	1520
Work Experience	Control	0.17	88	1.18	1.64	0	8
	Treatment	0.15	106	1.04	1.54	0	6
	Total	0.11	194	1.10	1.58	0	8
Voting Experience	Control	0.13	88	2.45	1.18	0	4
	Treatment	0.10	106	2.24	1.05	0	4

	Total	*0.08*	*194*	*2.34*	*1.11*	*0*	*4*
PV Knowledge	*Control*	*0.10*	*88*	*1.03*	*0.92*	*0*	*3*
	Treatment	*0.09*	*106*	*0.97*	*0.92*	*0*	*3*
	Total	*0.07*	*194*	*0.99*	*0.92*	*0*	*3*
AV Knowledge	*Control*	*0.09*	*88*	*0.55*	*0.86*	*0*	*2.5*
	Treatment	*0.08*	*106*	*0.51*	*0.82*	*0*	*3*
	Total	*0.06*	*194*	*0.53*	*0.84*	*0*	*3*
Factual Knowledge	*Control*	*0.14*	*88*	*4.49*	*1.30*	*0*	*0*
	Treatment	*0.11*	*106*	*4.58*	*1.09*	*5*	*5*
	Total	*0.09*	*194*	*4.54*	*1.19*	*0*	*5*

4.6.5 Other Factors

Session

The twelve sessions started at the following specific times: 9:05AM, 12:35PM, 2:20PM, 4:05PM, or 5:00PM. I coded them into four categories: morning session (9:05AM) code 1, noon session (12:35PM) code 2, early afternoon session (2:20PM and 4:05PM) code 3, and late afternoon session (5:00PM) code 4. Preliminary analysis showed no significant impact of Session, therefore, Session was not included in the final analysis.

Post-test Variables

There were four questions concerning how satisfied the subjects were with the learning process. The first question concerns the subjects' satisfaction with the learning process; the second concerns satisfaction with the sufficiency of the context in learning case(s); the third is self-reported confidence of answers; the last is a self-evaluation of AV knowledge as a result of the learning process. See Table 4-23 for descriptive statistics. The information was collected for future analysis, the hypotheses do not concern them.

Table 4-23. Descriptive Statistics – Satisfaction with Learning Process

	N	Minimum	Maximum	Mean	Std. Deviation
SatLearningProcess	182	1	5	3.50	.878
ContextSuff	181	1	5	3.78	.898

ConfidenceOfAnswer	178	1	5	3.19	.977
SelfEval	179	1	5	3.68	.803
Valid N (listwise)	178				

Other Demographic Information

Other demographic information collected about the subjects included class, gender, and U.S. citizenship. The sample frame of this study included students who registered in an introductory MIS course. There were four classes (taught by different instructors) in which the course was offered. To make sure there was no systematic differences in students from different classes, information of the class they came from was collected and analyzed. Crosstabs analysis and ANOVA analysis were run, there was no systematic difference found in either the independent variables, nor the dependent variables, nor the control variables across different classes. This is true for gender and being or not being a U.S. citizen as well.

4.7 Hypothesis Testing

Hypothesis testing in an experiment design involves a prior statement of the causal relationship followed by data analysis. This section gives the formal statement of hypotheses and the methods used for data analysis.

4.7.1 Hypotheses

Based on the conceptual model in Chapter 3 and the design details of the experiment, the following hypotheses are made. A graphic presentation of these hypotheses is in Figure 4-4.

H1: More flexible understanding of the knowledge content (FLUKC) leads to more effective KT.

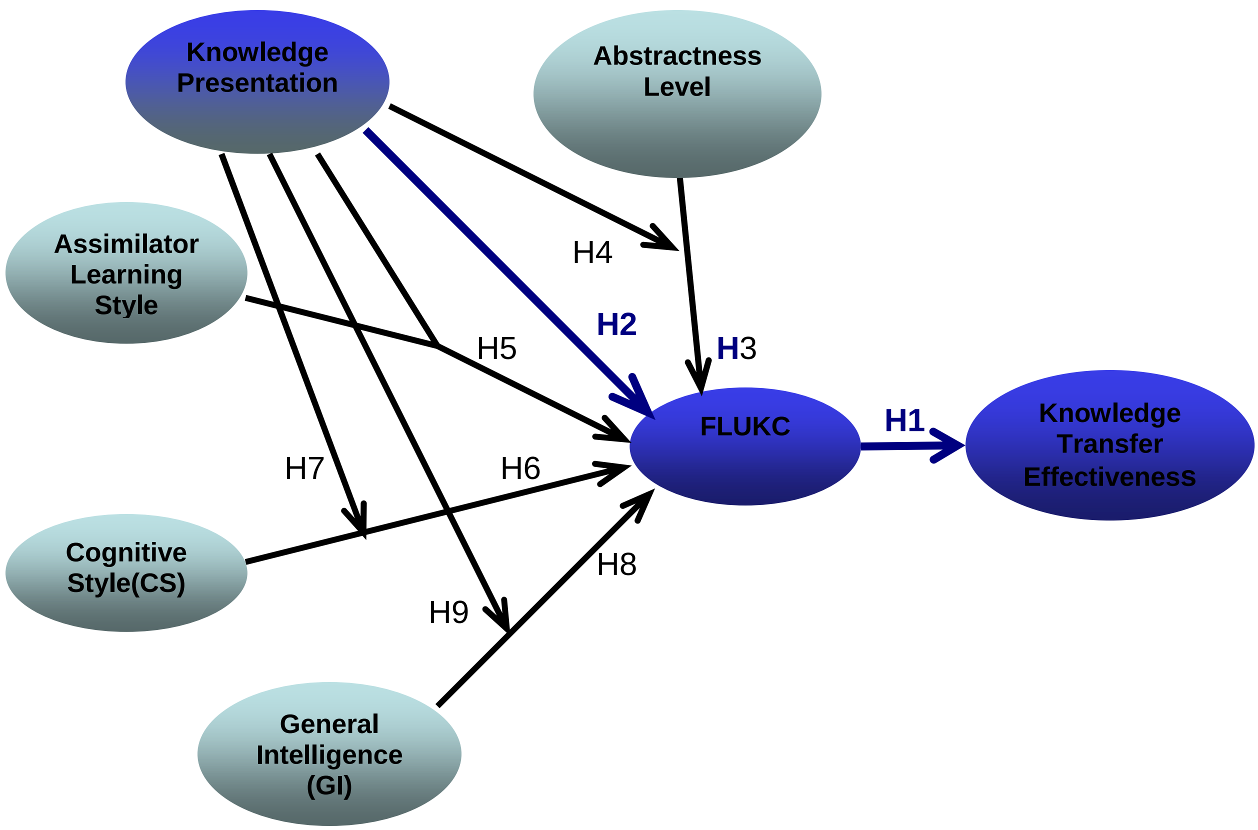


Figure 4-4. Model and Hypothesis

H2: Compared with the single-case control condition, the multi-case treatment condition leads to higher flexible understanding of the knowledge content learned in learning process.

H3: Subjects favoring the Abstract Conceptualization mode of learning will develop more flexible understanding of the knowledge content than subjects who prefer the Concrete Experience mode of learning.

H4: Under the multi-case treatment condition, the differences in FLUKC between subjects who prefer the Abstract Conceptualization mode of learning and subjects who prefer the Concrete Experience mode of learning will be smaller than the differences under the single-case control condition.

H5: Under the multi-case treatment condition, subjects who prefer the Assimilator learning style will develop more flexible understanding of the knowledge content than those who prefer other learning styles.

H6: Innovators on average develop more flexible understanding of the knowledge content than adaptors.

H7: Under the multi-case treatment condition, the differences in FLUKC between innovators and adaptors will be smaller than the differences under the single-case control condition.

H8: Individuals with high level general intelligence on average develop more flexible understanding of the knowledge content than those with lower level general intelligence.

H9: Under the multi-case treatment condition, the differences in FLUKC between high level intelligence individuals and low level intelligence individuals will be smaller than the differences under the single-case control condition.

4.7.2 Data Analysis Method

Table 4-24. gives the data analysis method used for each hypothesis. H1 tests the causal relationship between flexible understanding of the knowledge content and KT effectiveness. There were four FLUKC variables that are all correlated. Each one was used in a separate analysis. The four independent variables are the difference in the unweighted complexity (CFdiffH) and weighted complexity (CFdiffR), and the difference ratio of the unweighted complexity (CFRH1) and weighted complexity (CFRR1). They are all continuous variables. There were two dependent variables that assess KT effectiveness, KT2 is the sum of two application task scores, and KT5 is the sum of five application task scores. KT2 ranges from 0 to 4 and takes integer values only, KT5 ranges from 0 to 7 and takes integer values only. The score on the factual knowledge test was used as a covariate in the analysis. Linear regression was used to test H1.

Hypotheses H2 to H9 assess the effects on flexible understanding of the knowledge content. Flexible Understanding of the knowledge content was measured by CFdiffH, CFdiffR, CFRH1, and CFRR1. H2 hypothesizes the main effect of knowledge presentation (the treatment condition). The independent variable is a categorical variable for treatment – treatment condition vs. control condition. H3 hypothesizes the main effect of abstract conceptualization. The independent variable is a categorical variable for Abstractness Level – Concrete, Medium, and Abstract. H4 hypothesizes the interaction effect between knowledge presentation and abstract conceptualization. The H5 hypothesizes the interaction effect between knowledge presentation and the Assimilator learning style. Assimilator is a categorical variable for the learning style – Assimilator vs. non-Assimilator. H6 hypothesizes the main effect of cognitive style. The independent variable is a categorical variable for the Cognitive Style Category – Innovator vs. Adaptor. H7 hypothesizes the interaction effect between knowledge presentation and cognitive style. H8 hypothesizes the main effect of general intelligence. GPA and SAT scores are the surrogate measure for general intelligence. H9 hypothesizes the interaction effect between knowledge presentation and general intelligence.

The main and interaction effects of categorical independent variables on an interval dependent variable can be tested using the Analysis of Variance (ANOVA) technique (Creswell 2003). Analysis of Covariance (ANCOVA) is a similar technique which includes covariates in ANOVA to partial out their effects. ANOVA and ANCOVA analyze one dependent variable at a time. Multiple Analysis of Covariance (MANCOVA) is a statistical procedure for analyzing main and interaction effects of categorical variables on multiple interval dependent variables while controlling for the effects of continuous variables that covary with the dependents. Like the Analysis of Variance (ANOVA), MANCOVA is a two-stage test in which an overall (or omnibus) analysis is first performed before specific procedures are applied to further analyze group differences. While ANCOVA analyzes each dependent variable independently, MANCOVA took into account the correlations among the dependent variables. MANCOVA was applied to test Hypotheses H2 through H9 at the overall level, and then ANCOVA analyses were run to inspect the difference between groups in detail for each dependent variable. A rule of thumb for testing R-square is $N \geq 50 + 8m$ (Tabachnick et al. 2001) where m is the number of independent variables. The sample size (184) in this study met this requirement.

A summary of the hypotheses, the dependent and independent variables in each hypothesis, the covariates included in the analysis, and the method used for the analysis is provided in Table 4-24.

Table 4-24. Data Analysis Method for Hypotheses

Hypothesis	*Dependent Variable*	*Independent Variable*	*Control Variable*	*Statistical Method*
H1	KT5	CFdiffH	FacK	Linear Regression
	KT5	CFdiffR	FacK	Linear Regression
	KT2	CFdiffH	FacK	Linear Regression
	KT2	CFdiffR	FacK	Linear Regression
H2	CFdiffH CFdiffR CFRH1 CFRR1	Treatment	GPA, SAT, General voting experience, Prior AV Knowledge, Prior PV Knowledge, Work Experience	MANCOVA, ANCOVA
H3	CFdiffH CFdiffR CFRH1 CFRR1	Abstractness Level	GPA, SAT, General voting experience, Prior AV Knowledge, Prior PV Knowledge, Work Experience	MANCOVA, ANCOVA

H4	CFdiffH CFdiffR CFRH1 CFRR1	Treatment * Abstractness Level	GPA, SAT, General voting experience, Prior AV Knowledge, Prior PV Knowledge, Work Experience	MANCOVA, ANCOVA
H5	CFdiffH CFdiffR CFRH1 CFRR1	Treatment * Assimilator	GPA, SAT, General voting experience, Prior AV Knowledge, Prior PV Knowledge, Work Experience	MANCOVA, ANCOVA
H6	CFdiffH CFdiffR CFRH1 CFRR1	Cognitive Style Category	GPA, SAT, General voting experience, Prior AV Knowledge, Prior PV Knowledge, Work Experience	MANCOVA, ANCOVA
H7	CFdiffH CFdiffR CFRH1 CFRR1	Treatment * Cognitive Style Category	GPA, SAT, General voting experience, Prior AV Knowledge, Prior PV Knowledge, Work Experience	MANCOVA, ANCOVA
H8	CFdiffH CFdiffR CFRH1 CFRR1	GPA, SAT	GPA, SAT, General voting experience, Prior AV Knowledge, Prior PV Knowledge, Work Experience	MANCOVA, ANCOVA
H9	CFdiffH CFdiffR CFRH1 CFRR1	GPA * Treatment, SAT * Treatment	GPA, SAT, General voting experience, Prior AV Knowledge, Prior PV Knowledge, Work Experience	MANCOVA, ANCOVA

Chapter 5: Results and Discussion

This chapter presents the analysis and discussions. An overview of the hypotheses was presented at the beginning for the convenience of reading, detailed analysis follows.

5.1 Overview

Table 5-1 lists the hypotheses drawn from the research model. Hypothesis 1 is concerned with the effect of CF on knowledge transfer, subjects who can more easily change their mental models are hypothesized to perform better on problem-solving tasks. Hypotheses 2 through 9 are concerned with the influence on CF as a response variable. The treatment condition (multiple-case learning materials) is hypothesized to have positive influence on the readiness with which a subject can change his mental model (Hypothesis 2). Subjects who favor abstract conceptualization are hypothesized to have a positive influence on the readiness with which a subject can change his mental model (Hypothesis 3). Subjects with innovative cognitive style are hypothesized to more easily change their mental models than do adaptive subjects (Hypothesis 6). Subjects with high intelligence are hypothesized to more easily change their mental models than do subjects with lower intelligence (Hypothesis 8). In addition to the main effect, the treatment condition is hypothesized to moderate the influence of learning style, cognitive style, and intelligence (Hypothesis 4, 5, 7, and 9).

Hypothesis 1 was analyzed using linear regression. Hypotheses 2 through 9 were analyzed using MANCOVA and then independent univariate ANCOVA analyses. Multiple Analysis of Covariance (MANCOVA) is a statistical procedure for testing main and interaction effects of multiple categorical variables on multiple dependent interval variables while controlling the impacts of continuous covariates. MANCOVA took into account the correlations among the

Table 5-1. Hypothesis

Hypothesis	*Description*
Hypothesis 1: *More flexible understanding of the knowledge content (FLUKC) leads to more effective KT.*	*Main effect of FLUKC on performance*
Hypothesis 2: *Compared with the single-case control condition, the multi-case treatment condition leads to higher flexible understanding of the knowledge content learned in learning process.*	*Main effect of Knowledge Presentation*
Hypothesis 3: *Subjects favoring the Abstract Conceptualization mode of learning will develop more flexible understanding of the knowledge content than subjects who prefer the Concrete Experience mode of learning.*	*Main effect of Learning Style*
Hypothesis 4: *Under the multi-case treatment condition, the differences in FLUKC between subjects who prefer the Abstract Conceptualization mode of learning and subjects who prefer the Concrete Experience mode of learning will be smaller than the differences under the single-case control condition.*	*Interaction effect of Learning Style*
Hypothesis 5: *Under the multi-case treatment condition, subjects who prefer the Assimilator learning style will develop more flexible understanding of the knowledge content than those who prefer other learning styles.*	*Interaction effect of Learning Style*
Hypothesis 6: *Innovators on average develop more flexible understanding of the knowledge content than adaptors.*	*Main effect of Cognitive Style*
Hypothesis 7: *Under the multi-case treatment condition, the differences in FLUKC between innovators and adaptors will be smaller than the differences under the single-case control condition.*	*Interaction effect of Cognitive Style*
Hypothesis 8: *Individuals with high level general intelligence on average develop more flexible understanding of the knowledge content than those with lower level general intelligence.*	*Main effect of General Intelligence*
Hypothesis 9: *Under the multi-case treatment condition, the differences in FLUKC between high level intelligence individuals and low level intelligence individuals will be smaller than the differences under the single-case control condition.*	*Interaction effect of General Intelligence*

dependent variables, while ANCOVA analyzes each dependent variable independently. Both the multivariate and univariate analyses suggested that the impact of treatment conditions depend on the subjects' cognitive style, however, this interaction effect explains only a small portion of the variance in the CF measures. The univariate analyses showed similar interaction effects between the treatment condition and the subjects' learning style for CFdiffR and CFRR. Disappointingly, the regression analysis did not support the hypothesized relationship between CF and the performance of knowledge transfer tasks. Some reasons for this non-significant result will be discussed.

5.2 Hypotheses Testing

5.2.1 Cognitive Flexibility as the Dependent

In this study there are four continuous cognitive flexibility measures, three categorical independent variables, and continuous control variables. MANCOVA was run to test the relationships at the overall level, and then univariate ANCOVA analyses were run to inspect the difference between groups at detailed level.

Dependent Variables

Four dependent variables are used in the MANCOVA procedure. CFdiffH and CFdiffR are the absolute change in complexity in the first and second grouping step, respectively. CFRH1 and CFRR21 are the percentage change in complexity.

Independent Variables

The independent variables include categorical variable Treatment Condition (treatment and control condition), Cognitive Style (innovative and adaptive), and Abstract Level (concrete, middle, and abstract). This is a 2 x 2 x 3 design. The number of subjects for each cell is displayed in Table 5-2. This is not a balanced design as there are not equal numbers of subjects in each condition. Accordingly, Type III sums of squares were used in the calculations, which are invariant to the cell frequencies. As such, they can be used with unbalanced designs (Field 2005). At a minimum, MANCOVA requires that every cell must have more cases than there are dependent variables, which in this case is 4. This condition is met.

Table 5-2 Number of Subjects by Condition

Condition	***Cognitive Style***	***Learning Style***	Cell Size
Control			
	Adaptive	*Concrete*	**17**
		Middle	**19**
		Abstract	**13**
	Innovative	*Concrete*	**14**
		Middle	**12**
		Abstract	**9**
Treatment			
	Adaptive	*Concrete*	**21**
		Middle	**15**
		Abstract	**23**
	Innovative	*Concrete*	**17**
		Middle	**12**
		Abstract	**12**

The absence of multicollinearity among independent variables is required for MANCOVA analysis. Pearson Correlations between Treatment Condition, Learning Style, and Cognitive Style are non-significant; multicollinearity is not a problem in these data.

Covariates

The MANCOVA procedure allows including continuous control variables as covariates in the model. The following six covariates were included in the model to control for their potential impact on the dependent variables: GPA, SAT, General Voting Experience, Prior PV

Knowledge, Prior AV Knowledge, and Years of Work Experience. GPA and SAT are continuous and are used as covariates in the analysis, instead of independent variables to reduce the number of cells. Too many cells may reduce the power of the analysis if there are not sufficient subjects in each cell.

The MANCOVA Model

The model tested with MANCOVA is displayed in Table 5-3.

Table 5-3 MANCOVA Models

DV	Main Effect	Interaction	Convariate
CFdiffH CFdiffR CFRH1 CFRR1	Intercept Condition CogStyleCategory AbstractLevel	Condition * CogStyleCategory Condition1* AbstractLevel	VoteGeneral PVknowledge, AVKnowledge GPA, SAT YrsWrkExp

The Box's test is significant (significant level less than .001), indicating that the assumption of multivariate homoscedasticity fails to uphold. However, Box's M is extremely sensitive to violations of the assumption of normality. It has been shown to be a conservative test, rejecting the null hypothesis of equal variance too often. The Levene test investigates the equality of variances for each of the dependent variables. It is robust in the face of departures from normality. The Levene test shows that the error variance of the dependent variables is equal across groups (non-significant at the .05 level).

The only hypothesis supported by the experimental data is the interaction effect between Treatment Condition and Cognitive Style (Hypothesis 7). The F-statistics are significant at the .05 level, indicating that the values of the four dependant variables for all groups are significantly different. The four multivariate tests (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root) produced by MANCOVA for this effect are displayed in Table

5-4. Other hypotheses are not supported at the multiple analysis level. The conclusion that can be drawn from the interaction relationship is that the impact of Treatment Conditions on CF is moderated by the subject's cognitive style. Univariate analyses that focus on each of the four dependent variables separately were run to further investigate the group differences.

Table 5-4 Multivariate Test for Effects on FLUKC

	Term	*Statistics*				*Supported*
		Statistics	Value	F	Sig.	
H2	*Treatment Condition*	Pillai's Trace	0.047	2.039	0.091	*No*
		Wilks' Lambda	0.953	2.039	0.091	
		Hotelling's Trace	0.049	2.039	0.091	
		Roy's Largest Root	0.049	2.039	0.091	
		Statistics	Value	F	Sig.	
H3	*AbstractLevel*	Pillai's Trace	0.008	0.173	0.994	*No*
		Wilks' Lambda	0.992	0.172	0.994	
		Hotelling's Trace	0.008	0.172	0.994	
		Roy's Largest Root	0.008	0.330	0.857	
		Statistics	Value	F	Sig.	
H4	*Treatment * AbstractLevel*	Pillai's Trace	0.042	0.884	0.530	*No*
		Wilks' Lambda	0.959	0.882	0.532	
		Hotelling's Trace	0.043	0.880	0.533	
		Roy's Largest Root	0.035	1.439	0.223	
		Statistics	Value	F	Sig.	
H6	*CogStyleCategory*	Pillai's Trace	0.015	0.627	0.644	*No*
		Wilks' Lambda	0.985	0.627	0.644	
		Hotelling's Trace	0.015	0.627	0.644	
		Roy's Largest Root	0.015	0.627	0.644	
		Statistics	Value	F	Sig.	
H7	*Treatment * CogStyleCategory*	Pillai's Trace	0.064	2.806	0.027	*Yes*
		Wilks' Lambda	0.936	2.806	0.027	
		Hotelling's Trace	0.068	2.806	0.027	
		Roy's Largest Root	0.068	2.806	0.027	
		Statistics	Value	F	Sig.	
H8	*GPA*	Pillai's Trace	0.035	1.486	0.209	*No*
		Wilks' Lambda	0.965	1.486	0.209	
		Hotelling's Trace	0.036	1.486	0.209	
		Roy's Largest Root	0.036	1.486	0.209	

		Statistics	Value	F	Sig.	
H8	*SAT*	Pillai's Trace	0.040	1.700	0.152	*No*
		Wilks' Lambda	0.960	1.700	0.152	
		Hotelling's Trace	0.041	1.700	0.152	
		Roy's Largest Root	0.041	1.700	0.152	
		Statistics	Value	F	Sig.	
H9	*Treatment * GPA*	Pillai's Trace	0.043	1.825	0.126	*No*
		Wilks' Lambda	0.957	1.825	0.126	
		Hotelling's Trace	0.045	1.825	0.126	
		Roy's Largest Root	0.045	1.825	0.126	
		Statistics	Value	F	Sig.	
H9	*Treatment * SAT*	Pillai's Trace	0.043	1.829	0.126	*No*
		Wilks' Lambda	0.957	1.829	0.126	
		Hotelling's Trace	0.045	1.829	0.126	
		Roy's Largest Root	0.045	1.829	0.126	

The Interaction Effect

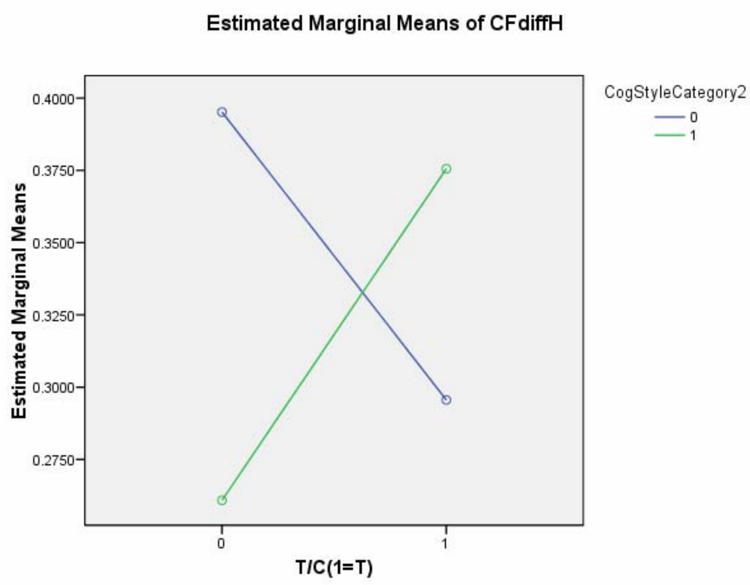
The Moderating Effect of Cognitive Style

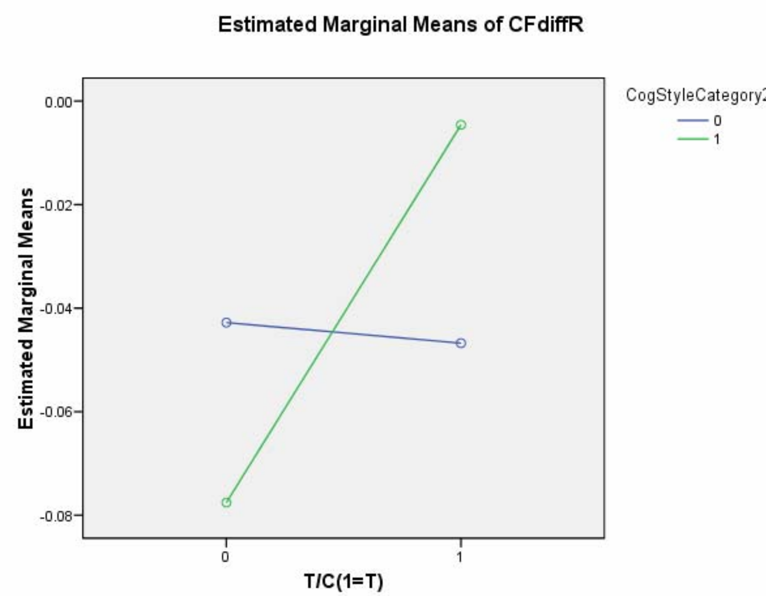
The hypothesis of the interaction effect between Treatment Condition and Cognitive Style is supported by the MANCOVA analysis. The means of the four dependent variables in the 2 by 2 table are listed in Table 5-5.

Table 5-5 Group Means – Cognitive Style by Condition

CF Measure	*Cognitive Style*	*Control*	*Treatment*
CFdiffH	*0*	*0.401*	*0.303*
	1	*0.276*	*0.389*
CFdiffR	*0*	*-0.042*	*-0.045*
	1	*-0.073*	*-0.010*
CFRH1	*0*	*0.298*	*0.185*
	1	*0.133*	*0.253*
CFRR1	*0*	*-0.012*	*-0.052*
	1	*-0.095*	*0.010*

Within the treatment groups, under the control condition, the adaptive subjects did better on average as suggested by the higher means on the four CF measures; on the contrary, under the


Estimated Marginal Means of CFdiffH
Estimated Marginal Means
0.4000
0.3750
0.3500
0.3250
0.3000
0.2750
0
1
T/C(1=T)
CogStyleCategory2
0
1


Estimated Marginal Means of CFdiffR
Estimated Marginal Means
0.00
-0.02
-0.04
-0.06
-0.08
0
1
T/C(1=T)
CogStyleCategory2
0
1

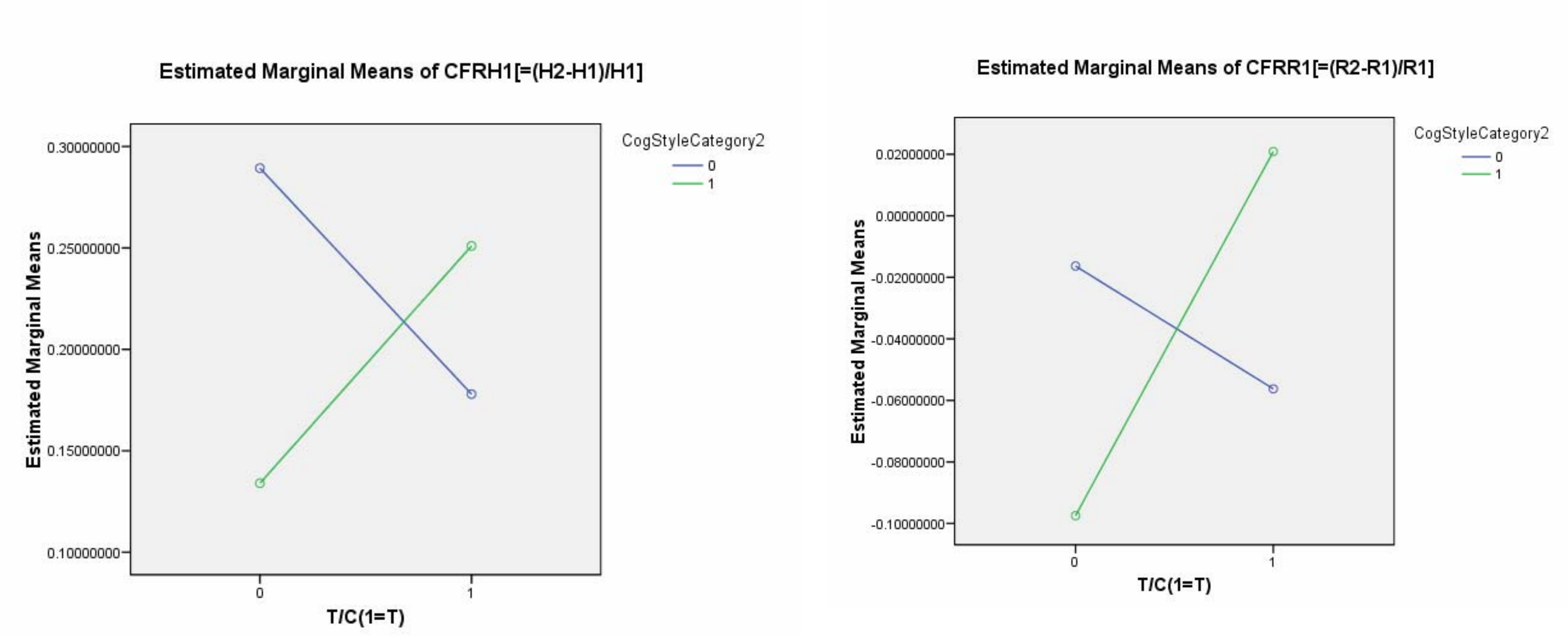


Figure 5-1. Interaction Effect – Cognitive Style by Condition

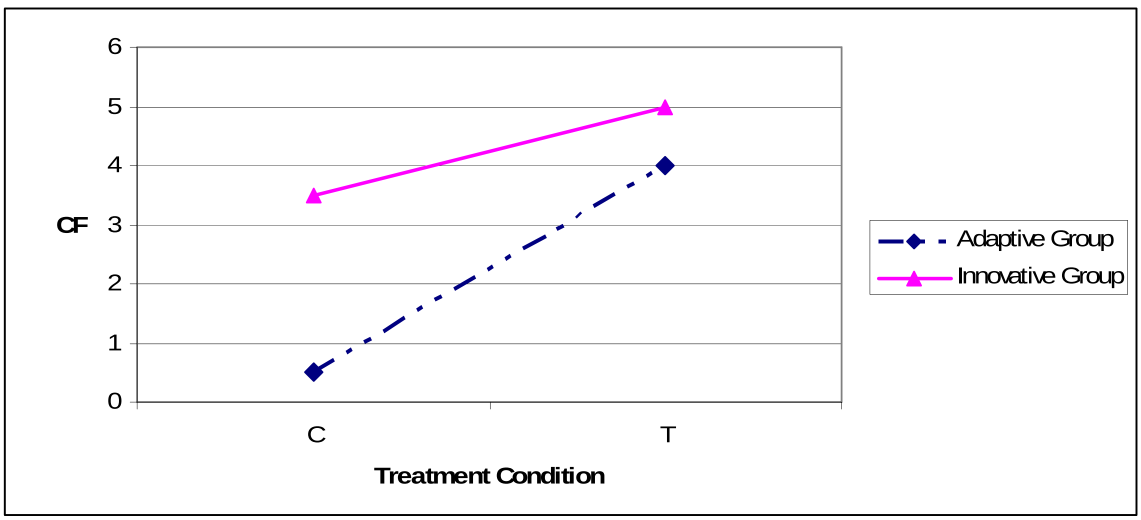
treatment condition, the innovative subjects did better on average. Across the treatment groups, the adaptive subjects did better under the control condition than under the treatment condition; the innovative subjects did better under the treatment condition than under the control condition. This pattern demonstrates the existence of the moderating effect. That is, the effect of treatment depends on the level of subjects' cognitive property. This pattern is depicted in Figure 5-1

As is depicted in Figure 5-1, the two lines representing the performance of the innovative group and the adaptive group intersect. The cross of the two lines suggests the absence of the main effect of either Treatment Condition or Cognitive Style. The cross is formed because the adaptive group did worse than the innovative group under the treatment condition and better than the innovative group under the control condition. Had there been any main effect of either Cognitive Style or Treatment Condition, the lines would have had no intersection but only different slopes.

The pattern depicted in Figure 5-1 contradicts what was initially proposed in the research model. It was initially hypothesized that CF would be higher for the innovative subjects within the same treatment condition (or when the treatment condition is held constant); and the difference in CF between the two groups would be smaller under the treatment condition than under the control condition. This pattern can be depicted in Figure 5-2.

Figure 5-2 shows a situation where both interaction effect and main effect exist. The upper line represents the CF measures for the innovative group under the control condition and treatment condition, respectively; the lower line represents the CF measures for the adaptive group under the control condition and treatment condition, respectively. Within either of the two treatment conditions, the innovative group has higher CF measure than the adaptive group; in other words, the marginal mean for innovative group is higher than the adaptive group. It suggests the existence of a main effect of Cognitive Style. Similarly, within the same cognitive style group, those under the Treatment Condition always have higher CF measures; in other words, the marginal mean of the treatment group is higher than that of the control group. On the other hand, the slope of the two lines are different, the adaptive group has a steeper slope than the innovative group. More specifically, although the treatment condition helped both cognitive groups, the adaptive group benefited more (because they might have more room to improve relative to their innovative counterparts). This interaction effect was what was initially proposed but not found in the data.

Figure 5-2 Interaction Effect with Main Effect Presence



The charts based on real data are displayed in Figure 5-1. The same pattern is shown in all four CF measures. There is no main effect of any kind. It is interesting to see that the innovative subjects did worse than the adaptive subjects under the control condition. Possible explanations will be included in the discussion session.

MANCOVA revealed that there are differences in the four dependent variables as a whole, follow-up univariate analysis was carried out to investigate if there are differences in each of the dependent variables. The results are discussed in the Univariate Analysis session.

The Moderating Effect of Learning Style

The interaction effect between Learning Style and Treatment Condition is not significant. Yet, the group means displayed a pattern of interaction similar to the moderating effect of Cognitive Style. As shown in Table 5-6, within treatment groups, subjects favoring abstract conceptualizing did worse than subjects favoring concrete experiencing under the control condition; the opposite is true under the treatment condition. Across treatment groups, subjects favoring concrete experiencing did better under the control condition than they did under the treatment condition; subjects favoring abstract conceptualizing did better under the treatment condition than they did under the control condition. It seems that the impact of Treatment Condition depends on the level of the subjects' preference for abstract conceptualizing. Univariate analyses and contrasts were run to test whether abstract conceptualizing moderates the impact of the Treatment Condition.

Another aspect of Learning Style that was posited (Hypothesis 5) to moderate the effect of treatment conditions is the Assimilator learning style. Assimilators are those who prefer abstract conceptualizing (AC-CE >= 12) and reflective observation (AE-RO <= 0). MANCOVA was run with the dummy variable for Assimilator replacing Abstract Level. No significant effect was observed, and Hypothesis 5 was not supported.

Table 5-6 Variable Means – Learning Style by Condition

CF Measure	Abstract Level	Control	Treatment
CFdiffH	-1	0.390	0.232
	0	0.400	0.295
	1	0.219	0.487
CFdiffR	-1	-0.042	-0.061
	0	-0.057	-0.019
	1	-0.071	-0.007
CFRH1	-1	0.247	0.157
	0	0.262	0.192
	1	0.160	0.290
CFRR1	-1	-0.032	-0.084
	0	-0.040	-0.006
	1	-0.077	0.021

The Main Effect

Four main effects were tested for the Treatment Condition, Learning Style, Cognitive Style, and General Intelligence. They were not supported. The main effect of Treatment Condition was non-significant. There was no significant difference in the marginal means of the dependent vector between the treatment and control group. As the interaction effect between Treatment Condition and Cognitive Style suggested, the effect of Treatment Condition depended on the subjects' Cognitive Style. The impact was not determined by Treatment Condition alone. Moreover, the interaction reflected a cross of the effects for the two cognitive styles under the two treatment conditions. In this case, no marginal difference was observed for the Treatment Condition. The story told by the data can be summarized as following: using the Control Condition as a baseline for comparison, one, under the Treatment Condition the subjects did NOT achieve more flexible understanding of the subject matter on average; two, the Treatment Condition did help the innovative subjects to achieve more flexible understanding; and three, the

Treatment Condition seemed to have undermined the adaptive subjects as their CF scores were worse on average than their counterparts in the control group.

The main effect of Cognitive Style was not supported. There was no significant difference between subjects who favor adaptive thinking and those who favor innovative thinking in the CF measures across levels of other variables. The main effect of Learning Style was not supported by the data. There was no significant difference between the subjects favoring abstract conceptualizing and those favoring concrete experiencing across levels of other variables. The main effect of General Intelligence was not supported either. Neither GPA nor SAT score had significant main or moderating impact on the dependent variables.

Univariate Analysis

Following the significant results of interaction effect in MANCOVA, univariate analyses were carried out to investigate if and where there are differences in individual dependent variables. Four ANOVA analyses were carried out, one for each dependent variable. The same three categorical variables (Treatment Condition, Cognitive Style, Learning Style) and six covariates used in the MANCOVA model were used in these univariate analyses.

Analysis of CFdiffH (Change in Absolute Complexity)

Overall Difference

CFdiffH is the difference in absolute complexity between the first and second grouping. No overall difference in CFdiffH among the groups was discovered. There is no interaction effect between Treatment Condition and Cognitive Style ($F=1.664$, Sig. = 0.199) or between Treatment Condition and Learning Style at the .05 level, however, there is interaction between Learning Style and Treatment Condition at the .10 level ($F=2.477$, Sig. = 0.087). There are three levels of abstractness level, abstract, middle, and concrete. As the group means of showed interaction pattern (see The Moderating Effect of Learning Style and Table 5-6) though not statistically significant, contrasts between each pair of groups were conducted to elucidate the nature of possible interactions.

Table 5-7 Between-Subjects Effects – CFdiffH

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	*Observed Power*
Corrected Model	*5.421*	*13*	*0.417*	*1.057*	*0.400*	*0.623*
Intercept	*0.052*	*1*	*0.052*	*0.131*	*0.718*	*0.065*
Condition1T	*0.046*	*1*	*0.046*	*0.118*	*0.732*	*0.063*
CogStyleCategory	*0.001*	*1*	*0.001*	*0.001*	*0.970*	*0.050*
AbstractLevel	*0.059*	*2*	*0.030*	*0.075*	*0.928*	*0.061*
*Condition1T * CogStyleCategory*	*0.656*	*1*	*0.656*	*1.664*	*0.199*	*0.250*
*Condition1T * AbstractLevel*	*1.954*	*2*	*0.977*	*2.477*	***0.087***	*0.492*
Error	*67.451*	*171*	*0.394*			
Total	*95.568*	*185*				
Corrected Total	*72.872*	*184*				

R Squared = .074 (Adjusted R Squared = .004)

Contrasts between Groups

There are three categories in Abstractness Level (Abstract, Middle, Concrete), three pairwise contrasts were carried out to investigate (1) if the Treatment Condition effect is different between the Concrete and Abstract subjects; (2) if the Treatment Condition effect is different between the Middle and Abstract subjects; and (3) if the if the Treatment Condition effect is different between the Middle and Concrete subjects. Table 5-8 summaries the results of these contrasts. The contrasts are non-significant at the .05 level between.

Table 5-8 Contrast of the Interaction Effect of Abstractness Level on CFdiffH

Contrast	*PE*	*SE*	*MSE*	*df*	*t*	*p (Two-Tailed)*
Concrete, Abstract by Treatment, Control	*-0.426*	*0.229*	*0.394*	*171*	*-1.864*	*0.064*
Middle, Abstract by Treatment, Control	*-0.324*	*0.237*	*0.394*	*171*	*-1.370*	*0.173*
Concrete, Middle by Treatment, Control	*-0.102*	*0.223*	*0.394*	*171*	*-0.456*	*0.649*

The parameter estimate (PE) of the interaction effect is the discrepancy in the difference between Abstractness Levels across treatment conditions. SE is the estimated standard error of PE. MSE is the mean square error of the overall ANOVA analysis. Df is the degree of freedom of the ANOVA MSE as well as the degree of freedom for the t-test of PE. For instance, PE for the contrast between the Concrete and Abstract group (coefficient = -0.426, Sig. = 0.032) is the discrepancy between the mean difference of the Concrete and Abstract group for the Treatment Condition (0.232-0.487 = -0.255) and the counterpart for the Control Condition (0.390-0.219 = 0.171). The absolute discrepancy between the two differences, or [$CFdiffH_{(Concrete, Treatment)}$ - $CFdiffH_{(Abstract, Treatment)}$] - [$CFdiffH_{(Concrete, Control)}$ - $CFdiffH_{(Abstract, Control)}$], is therefore - 0.426 (-0.255 - 0.171). The t-test (t = -1.864, p = 0.064) is not significant at the .05 level. Actually, it is in the opposite direction to what was expected. The hypothesis of the interaction effect (Hypothesis 4) has a predicted direction. Specifically, the hypothesis proposed that the difference between the abstract learners and others will be smaller under the treatment condition than under the control condition. The t-test suggests that the difference between the concrete and abstract subjects under the treatment condition is greater than it is under the control condition, although it is not significant.

Analysis of CFdiffR (Change in Weighted Complexity)

<u>*Overall Difference*</u>

The interaction effect between Treatment Condition and Cognitive Style (F=3.166, Sig. = 0.077) is near significant at the .05 level. A contrast between groups was carried out to further investigate the difference. There is no interaction effect between Treatment Condition and Learning Style (F = 1.593, Sig. = 0.206).

Table 5-9 Between-Subjects Effects – CFdiffR

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	*Observed Power*
Corrected Model	*0.428*	*13*	*0.033*	*1.475*	*0.131*	*0.804*
Intercept	*0.013*	*1*	*0.013*	*0.588*	*0.444*	*0.119*
Condition1T	*0.065*	*1*	*0.065*	*2.905*	*0.090*	*0.396*
CogStyleCategory	*0.004*	*1*	*0.004*	*0.173*	*0.678*	*0.070*
AbstractLevel	*0.014*	*2*	*0.007*	*0.319*	*0.727*	*0.100*
*Condition1T * CogStyleCategory*	*0.071*	*1*	*0.071*	*3.166*	***0.077***	*0.425*
*Condition1T * AbstractLevel*	*0.071*	*2*	*0.036*	*1.593*	*0.206*	*0.334*
Error	*3.816*	*171*	*0.022*			
Total	*4.533*	*185*				
Corrected Total	*4.244*	*184*				

R Squared = .101 (Adjusted R Squared = .032)

Contrasts between Groups

The contrast between the difference in means of the Innovative and Adaptive subjects under the Treatment Condition and that under the Control Condition is non-significant at the .05 level. The difference in CFdiffR between the innovative group and adaptive group under the treatment condition and control condition is .044, and -0.031, respectively. The absolute difference of this discrepancy between the two conditions is therefore 0.075 (0.075 = 0.031 + 0.0.044).

Table 5-10 Contrast of the Interaction Effect of Cognitive Style on CFdiffR

Contrast	*PE*	*SE*	*MSE*	*df*	*t*	*p (Two-Tailed)*
Adaptive, Innovative by Treatment, Control	*-0.075*	*0.044*	*0.022*	*171*	*-1.691*	*0.093*

Analysis of CFRH1 (Percentage Change in Absolute Complexity)

Overall Difference

The interaction effect between Treatment Condition and Cognitive Style (F=4.364, Sig. = 0.038) is significant at the .05 level. The interaction effect between Treatment Condition and Learning Style (F=2.470, Sig. = 0.088) is significant at the .10 level.

Table 5-11 Between-Subjects Effects – CFRH1

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	*Observed Power*
Corrected Model	*2.699*	*13*	*0.208*	*1.640*	*0.079*	*0.854*
Intercept	*0.009*	*1*	*0.009*	*0.070*	*0.792*	*0.058*
Condition1T	*0.000*	*1*	*0.000*	*0.002*	*0.968*	*0.050*
CogStyleCategory	*0.070*	*1*	*0.070*	*0.553*	*0.458*	*0.115*
AbstractLevel	*0.006*	*2*	*0.003*	*0.023*	*0.977*	*0.053*
*Condition1T * CogStyleCategory*	*0.553*	*1*	*0.553*	*4.364*	***0.038****	*0.547*
*Condition1T * AbstractLevel*	*0.626*	*2*	*0.313*	*2.470*	***0.088***	*0.491*
Error	*21.524*	*170*	*0.127*			
Total	*33.184*	*184*				
Corrected Total	*24.223*	*183*				

R Squared = .111 (Adjusted R Squared = .043)

<u>*Contrasts between Groups*</u>

Abstractness Level

Three pairwise contrasts were conducted for Abstractness Level to further investigate the nature of the interaction. The differences between group means in all pairs are not significant.

Table 5-12 Contrast of the Interaction Effect of Abstractness Level on CFRH1

Contrast	*PE*	*SE*	*MSE*	*df*	*t*	*p (Two-Tailed)*
Concrete, Abstract by Treatment, Control	*-0.219*	*0.130*	*0.127*	*170*	*-1.684*	*0.094*
Middle, Abstract by Treatment, Control	*-0.199*	*0.135*	*0.127*	*170*	*-1.477*	*0.142*
Concrete, Middle by Treatment, Control	*-0.019*	*0.127*	*0.127*	*170*	*-0.151*	*0.880*

Cognitive Style

The contrast of the difference in means of the Innovative and Adaptive subjects under the Treatment Condition and that under the Control Condition is significant at the .05 level ($t = -2.170$, $p = 0.031$). As noted before, the adaptive group under the control condition had higher CFRH1 scores than the innovative group under the same condition; it was the opposite under the treatment condition – the innovative group had higher CRRH1 scores than the adaptive group.

The group difference under the control condition CFRH1$_{(\text{Innovative, Control})}$ - CFRH1$_{(\text{Adaptive, Control})}$ is -0.165, the group difference under the treatment condition CFRH1$_{(\text{Innovative, Treatment})}$ - CFRH1$_{(\text{Adaptive, Treatment})}$ is 0.067. The absolute difference between the two group differences is 0.232.

Table 5-13 Contrast of the Interaction Effect of Cognitive Style on CFRH1

Contrast	*PE*	*SE*	*MSE*	*df*	*t*	*p (Two-Tailed)*
Adaptive, Innovative by Treatment, Control	*-0.232*	*0.107*	*0.129*	*170*	*-2.170*	***0.031****

Analysis of CFRR1 (Percentage Change in Weighted Complexity)

<u>*Overall Difference*</u>

The interaction effect between Treatment Condition and Cognitive Style (F=3.434, Sig. = 0.066) is near significant at the .05 level. The interaction effect between Treatment Condition and Learning Style (F=1.678, Sig. = 0.190) is not significant.

Table 5-14 Between-Subjects Effects – CFRR1

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	*Observed Power*
Corrected Model	*1.315*	*13*	*0.101*	*1.449*	*0.142*	*0.795*
Intercept	*0.006*	*1*	*0.006*	*0.083*	*0.773*	*0.059*
Condition1T	*0.054*	*1*	*0.054*	*0.770*	*0.381*	*0.141*
CogStyleCategory	*0.000*	*1*	*0.000*	*0.002*	*0.963*	*0.050*
AbstractLevel	*0.032*	*2*	*0.016*	*0.232*	*0.793*	*0.086*
*Condition1T * CogStyleCategory*	*0.240*	*1*	*0.240*	*3.434*	*0.066*	*0.453*
*Condition1T * AbstractLevel*	*0.234*	*2*	*0.117*	*1.678*	*0.190*	*0.350*
Error	*11.872*	*170*	*0.070*			
Total	*13.421*	*184*				
Corrected Total	*13.188*	*183*				

R Squared = .100 (Adjusted R Squared = .031)

Contrasts between Groups

Cognitive Style

The contrast between the difference in means of the Innovative and Adaptive subjects under the Treatment Condition and that under the Control Condition is non-significant at the .05 level (t = -1.807, p = 0.073).

Table 5-15 Contrast of the Interaction Effect of Cognitive Style on CFRR1

Contrast	***PE***	***SE***	***MSE***	***df***	***t***	***p (Two-Tailed)***
Adaptive, Innovative by Treatment, Control	*-0.144*	*0.080*	*0.070*	*170*	*-1.807*	*0.073*

5.2.2 Cognitive Flexibility as Independent

Knowledge Transfer is of ultimate interest in this research. Hypothesis 1 proposes that higher CF leads to better knowledge transfer performance. The CF measures are explanatory variables in this proposed relationship, while the scores of problem-solving tasks are the dependent variables.

Dependent Variables

Two measures (KT5 and KT2) of the performance of knowledge transfer were created based on five problem-solving task scores, Tasl1.16, Task2.18, Task2.20, Task3.S1, and Task3.S2. KT5 is the sum of all five scores, KT2 is the sum of Task3.S1 and Task3.S2. The descriptive statistics of KT2, KT5, and Tasl1.16, Task2.18, Task2.20, Task3.S1 Task3.S2 are in Table 5-16.

Independent Variables

The four measures of cognitive flexibility are highly correlated with each other and not suitable to use as independent variable together in statistical analysis. CFdiffH (the difference between the absolute complexity in the first step and the second step) and CFdiffR (the difference between the weighted complexity in the first step and that in the second step) were used as the independent variable in separate regression models to test the relationship.

Control Variable

The actual knowledge learned is expected to affect the knowledge transfer performance. The factual test score was used as the measure of the degree to which a student subject mastered the basic factual knowledge of the topic. Factual test score was used in the regression model as a control variable.

Table 5-16 Descriptive Statistics – Dependent Variable

Variable	*Score*	*Frequency*	*Percent*	*Valid Percent*	*Cumulative Percent*
Task1.16					
	0	*68*	*35.052*	*35.052*	*35.052*
	1	*126*	*64.948*	*64.948*	*100.000*
	Total	*194*	*100.000*	*100.000*	
Task2.18					
	0	*55*	*28.351*	*28.351*	*28.351*
	1	*139*	*71.649*	*71.649*	*100.000*
	Total	*194*	*100.000*	*100.000*	
Task2.20					
	0	*100*	*51.546*	*51.546*	*51.546*
	1	*94*	*48.454*	*48.454*	*100.000*
	Total	*194*	*100.000*	*100.000*	
Task3.S1					
	0	*21*	*10.825*	*10.995*	*10.995*
	1	*77*	*39.691*	*40.314*	*51.309*
	2	*93*	*47.938*	*48.691*	*100.000*
	Total	*191*	*98.454*	*100.000*	
Task3.S2					
	0	*13*	*6.701*	*6.806*	*6.806*
	1	*11*	*5.670*	*5.759*	*12.565*
	2	*167*	*86.082*	*87.435*	*100.000*
	Total	*191*	*98.454*	*100.000*	
KT2					
	0	*10*	*5.155*	*5.236*	*5.236*
	1	*3*	*1.546*	*1.571*	*6.806*
	2	*20*	*10.309*	*10.471*	*17.277*
	3	*67*	*34.536*	*35.079*	*52.356*
	4	*91*	*46.907*	*47.644*	*100.000*

	Total	*191*	*98.454*	*100.000*	
KT5					
	0	*3*	*1.546*	*1.571*	*1.571*
	1	*3*	*1.546*	*1.571*	*3.141*
	2	*5*	*2.577*	*2.618*	*5.759*
	3	*19*	*9.794*	*9.948*	*15.707*
	4	*30*	*15.464*	*15.707*	*31.414*
	5	*46*	*23.711*	*24.084*	*55.497*
	6	*56*	*28.866*	*29.319*	*84.817*
	7	*29*	*14.948*	*15.183*	*100.000*
	Total	*191*	*98.454*	*100.000*	

Models

The following four regression models were tested:

(1) KT5 = intercept + CFdiffH + Factual

(2) KT2 = intercept = CFdiffH + Factual

(3) KT5 = intercept + CFdiffR + Factual

(4) KT2 = intercept + CFdiffR + Factual

Model Summary

The F tests suggested the significance of the regression model in all four cases. All four F tests are significant at the .05 level (Table 5-17). However, the independent variable is not significant in all models (Table 5-18), Factual Knowledge accounts for most of the explained variance in the dependent variable, and the R-Squared is low for each model (less than 10%).

The assumptions of regression analysis were checked, and it was found that two reasons might have contributed to the lack of fit of the models and the non-significance of the independent variable. First, the dependent variables are not normally distributed; second, there may be a nonlinear relationship between the dependent and independent variable.

Table 5-17 Model Summary

Model	Model Specification	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson	F	Sig.
1	$KT5 = CFdiffH + Factual$	0.270	0.073	0.063	1.483	1.881	7.402	0.001
2	$KT2 = CFdiffH + Factual$	0.203	0.041	0.031	1.026	2.057	4.052	0.019
3	$KT5 = CFdiffR + Factual$	0.272	0.074	0.064	1.482	1.885	7.525	0.001
4	$KT2 = CFdiffR + Factual$	0.203	0.041	0.031	1.027	2.073	4.020	0.020

Table 5-18 Coefficient Table

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.465	0.425		8.147	0.000		
	Factual	0.346	0.090	0.270	3.844	0.000	1.000	1.000
	CFdiffH	-0.037	0.171	-0.015	-0.214	0.830	1.000	1.000
2	(Constant)	2.381	0.294		8.087	0.000		
	Factual	0.170	0.062	0.195	2.727	0.007	1.000	1.000
	CFdiffH	0.092	0.118	0.056	0.779	0.437	1.000	1.000
3	(Constant)	3.448	0.422		8.177	0.000		
	Factual	0.343	0.090	0.268	3.813	0.000	0.998	1.002
	CFdiffR	-0.376	0.716	-0.037	-0.525	0.600	0.998	1.002
4	(Constant)	2.415	0.292		8.266	0.000		
	Factual	0.173	0.062	0.198	2.771	0.006	0.998	1.002
	CFdiffR	0.366	0.496	0.053	0.738	0.461	0.998	1.002

Assumptions

Independent Observations

Regression analysis assumes the independence among observations. As a rule of thumb, the Durbin-Watson coefficient is should be between 1.5 and 2.5 to indicate independence of observations. The Durbin-Watson coefficients for all four Models are between 1.88 and 2.07; the assumption of independent observations was met for all models.

Absence of Multicollinearity

In regression models multicollinearity is an unacceptably high level of intercorrelation among the independent variables. As a rule of thumb, if tolerance is less than .20, a problem with multicollinearity is indicated. The variance-inflation factor (VIF) is simply the reciprocal of tolerance. VIF >= 4 is an arbitrary but common cut-off criterion for multicollinearity. The tolerance and VIF of Model 1 through Model 4 are all very close to 1, there is no indication of collinearity between the two independent variables in each model.

Normality Check

A normal distribution is assumed by the regression procedure. Skewness is the tilt in a distribution. The skewness should be within the +2 to -2 range when the data are normally distributed. Kurtosis is the peakedness of a distribution. Kurtosis also should be within the +2 to -2 range when the data are normally distributed. The skewness and kurtosis for both KT2 and KT5 fall in this range. Shapiro-Wilks test is a formal test of normality recommended for small and medium samples up to n = 2000. The Shapiro-W is significant for both variables, indicating that the distribution is not normal.

Table 5-19 Test of Normality

Variable	*Kolmogorov-Smirnov*			*Shapiro-Wilk*			*Skewness*	*Kurtosis*
	Statistic	*df*	*Sig.*	*Statistic*	*df*	*Sig.*		
KT5	*0.184*	*191*	*0.000*	*0.902*	*191*	*0.000*	*-0.923*	*0.851*
KT2	*0.260*	*191*	*0.000*	*0.736*	*191*	*0.000*	*-1.584*	*2.350*

Linearity

Regression assumes linear relationship between the dependent and independent variables. An inspection of the scatterplot of standardized residuals against standardized estimates is a common

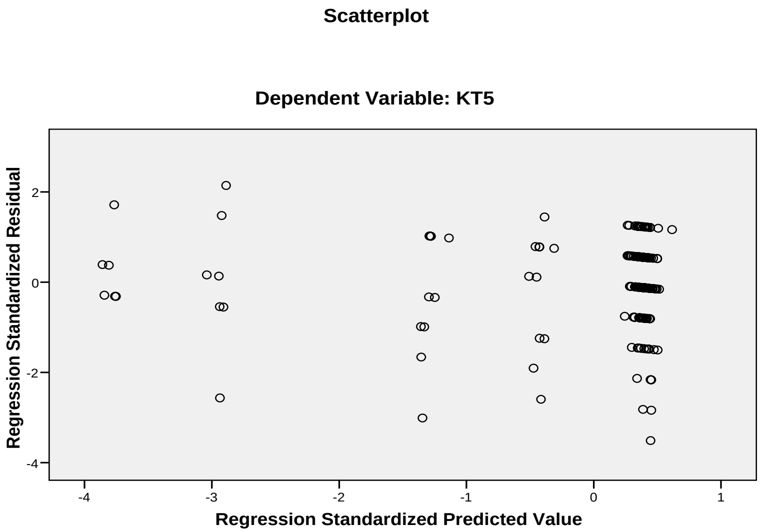


Figure 5-3 a. Normality Check (Model 1)

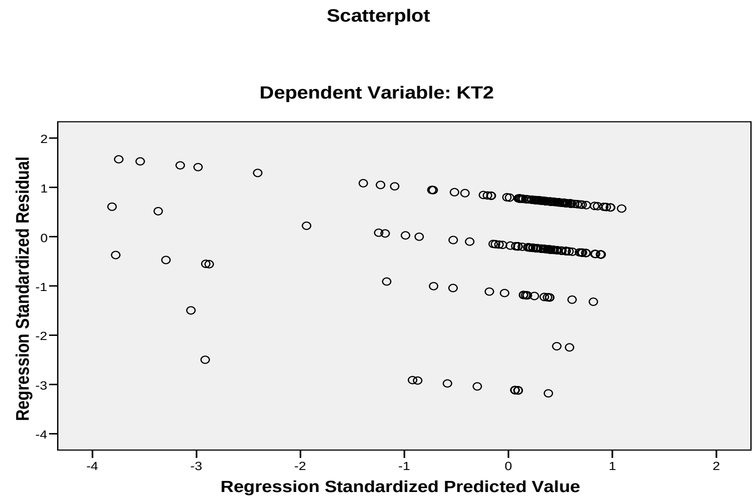


Figure 5-3 b. Normality Check (Model 2)

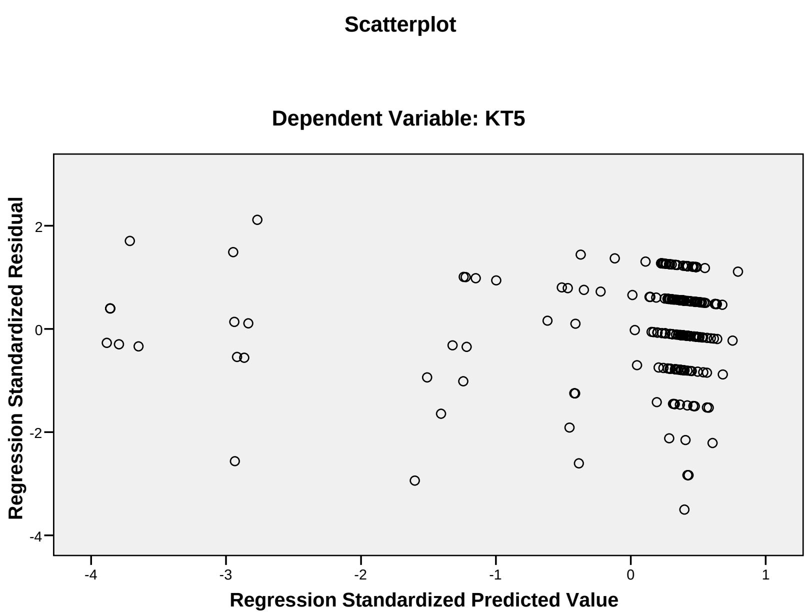


Figure 5-3 c. Normality Check (Model 3)

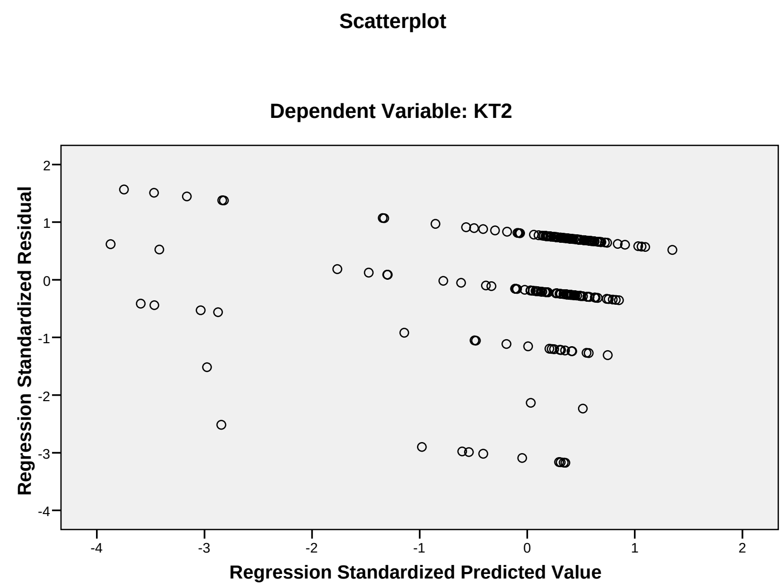


Figure 5-3 d. Normality Check (Model 4)

Figure 5-3 Scatterplot of Standardized Residuals against Standardized Estimates method of determining if nonlinearity exists in a relationship. A plot of standardized residuals against standardized estimates (fitted values) of the dependent variable should show a random pattern when nonlinearity is absent. These plots (see Figure 5-3) of all four models show apparent downward trend. This suggests that the relationship between the independent and dependent might be non-linear.

Chi-Square Test

As discussed above, the dependent variables do not follow a normal distribution. This could be caused by the fact that the test scores can assume only integer values ranging from 0 to 4 for KT2 and 0 to 7 for KT5. Therefore, the two variables are more categorical than continuous. Accordingly, a Chi-Square test was used to see if there is any relationship between KT performance and CF by analyzing the frequencies of KT performance (KT2 and KT5) in different levels of CF.

Categorical variables based on the continuous variables CFdiffH and CFdiffR were created. CFdiffHCat and CFdiffRCat were created for CFdiffH and CFdiffR according to the scheme in Table 5-20, respectively. Zero represents low CF for both the change in H (the change in the absolute complexity) and R (the weighted complexity). One represents mid-level CF, and two represents high level CF.

Table 5-20 CF Categorical Measures

CFdiffH	*Lowest thru 0*	*0 thru 1*	*1 thru Highest*
CFdiffHCat	*0*	*1*	*2*
CFdiffR	*Lowest thru 0*	*0 thru 0.25*	*0.25 thru Highest*
CFdiffRCat	*0*	*1*	*2*

Chi-Square tests showed no significant difference in the frequencies of the test scores in different CF categories. Pearson Chi-Square is 12.194 (Sig. = 0.591) for KT5 against CFdiffHCat, 7.430 (Sig. = .491) for KT2 against CFdiffHCat, 18.606 (Sig. = 0.181) for KT5 against CFdiffRCat, and 8.381 (Sig. = 0.397) for KT2 against CFdiffRCat.

5.3 Post-hoc Analysis

5.3.1 Converging Learning Style

One with converging learning style prefers abstract conceptualizing (AC-CE ≥ 12) and Active Experimentation (AE-RO ≥ 12). See Figure 5-4. About 24% of the subjects were Convergers. With the dummy variable for abstract conceptualizing replaced by one for Converger (CONV), MANCOVA analysis was run to test the impact of the converging learning style and its interaction with the treatment condition on flexible understanding of the knowledge content. The result was not significant.

5.3.2 Two Level Abstract Conceptualizing

In the previous analysis, the preference for abstract conceptualizing (the AC-CE dimension in Figure 5-4) was divided into three categories. The subjects who had an AC-CE score lower than 2 were categorized to the Concrete group, those whose AC-CE score were higher than 12 were categorized to the Abstract group, and those in the middle were categorized to the Medium group. The three-way division was based on the consideration that people in the middle do not have a strong preference for abstract conceptualizing versus concrete experiencing. A two-way division was used to reanalyze the data. The point of division was 7 on the AC-CE dimension. A binary dummy variable (AbstThk2Level) for abstract conceptualizing was created, AC-CE numbers lower than 7 transformed to 0 for the dummy variable, and AC-CE numbers greater than or equal to 7 transformed to 1. Slightly more than half of the subjects (53.1%) preferred concrete experiencing.

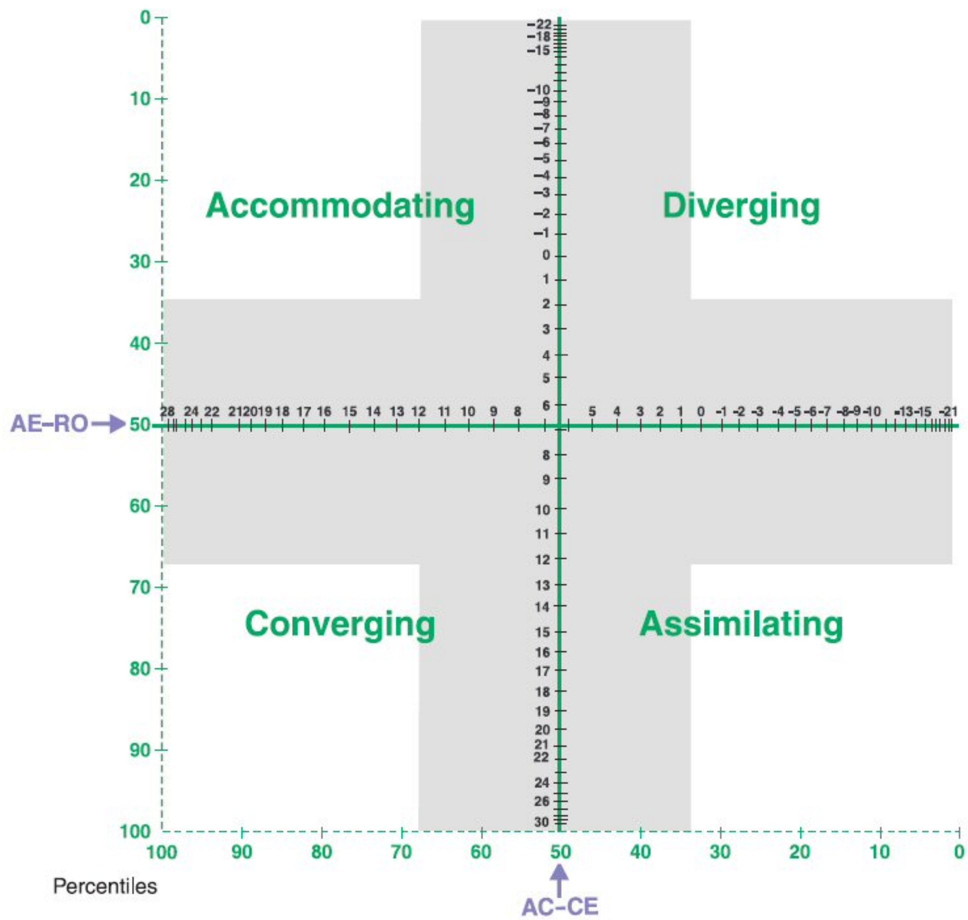


Figure 5-4. Kolb's Learning Style

The binary dummy variable (AbstThk2Level) was used replacing the three-level dummy variable for abstract conceptualizing in MANCOVA analysis to test the relationship between abstract conceptualizing and flexible understanding. The proportion of explained variance by abstract conceptualizing was increased using the binary variable as opposed to using the three-level variable. The Pillai's Trace is 0.018 ($F = 0.796$, $p = 0.529$) for the binary variable, and 0.009 ($F = 0.186$, $p = 0.993$) for the three-level variable, although the effect was still non-significant.

5.3.3 KT Effectiveness

In the analysis of KT effectiveness, the five task performance scores were mapped into two variables, KT5 and KT2. KT5 was the sum of all application task scores (namely, Task1.16, Task2.18, Task2.20, Task3.S1, and Task3.S2), KT2 was the sum of the two Task 3 scores (Task3.S1 and Task3.S2). Post-hoc analysis showed salient differences in the five scores. Three of the five variables (Task1.16, Task2.18, and Task3.S2) were significantly correlated with the Factual Knowledge Test (FacK) score, the other two (Task2.20 and Task3.S1) were not correlated with the Factual Knowledge Test score. These five variables were used as dependent variable in regression analyses with FacK as one of the explanatory variables, the coefficient of FacK was significant for Task1.16, Task2.18, and Task3.S2, but not for Task2.20 and Task3.S1. This indicates that to reach the correct answer or produce a high quality solution for Task2.20 and Task3.S1, factual knowledge alone is not sufficient, and knowledge transfer is required in these cases. In fact, Task1.16, Task2.18, and Task3.S2 share more similarity with questions that have straightforward answers such as Task1.15, Task2.17, and Task2.19 than with Task2.20 and Task3.S1. Table 5-21 indicates that a high percentage of subjects was able to give a straightforward answer. For instance, 80.93% of all subjects answered Task1.15 correctly, 79.9% answered Task2.17 correctly, and 87.11% answered Task2.19 correctly. A good amount of people answered Task3.S2, Task1.16, and Task2.18 correctly. Specifically, 86.08% of all subjects got the highest score on Task3.S2, 64.95% of all answered correctly on Task1.16, and 71.65% answered correctly on Task2.18. However, for Task2.20 and Task3.S1, the percentage for subjects who answered correctly or gave the best answer was much lower (48.45% for Task2.20 and 47.94% for Task3.S1).

Table 5-21. Task Scores

	Score	Frequency	Percent
Task1.15	0	37	19.07%
	1	157	80.93%
Tas2.17	0	39	20.10%
	1	155	79.90%
Task2.19	0	25	12.89%
	1	169	87.11%
Task3.S2	0	13	6.70%
	1	11	5.67%
	2	167	86.08%
Task1.16	0	68	35.05%
	1	126	64.95%
Task2.18	0	55	28.35%
	1	139	71.65%
Task2.20	0	100	51.55%
	1	94	48.45%
Task3.S1	0	21	10.82%
	1	77	39.69%
	2	93	47.94%

This might indicate that Task2.20 and Task3.S1 needed knowledge transfer more than the other tasks. In fact, the correct answer of Task2.20 might have contradicted most subjects' impression of Approval Voting. AV was introduced as a 'better' alternative to Plurality Voting (PV), and due to the limited time on the experiment session, the reading materials had been more or less biased toward the advantages of AV over PV. Yet, in the scenario of Task2.20, while PV meets the *Majority Criterion,* a criterion that is supposed to be fair and just (see Appendix B.3), AV does not meet this criterion. This contradiction might have been the main reason that a lot of people did not get the right answer. More interestingly, Task2.20 was closely related to

Task2.19, in which the subjects were asked to decide which candidate had won the hypothetic election in the question. With 87.11% of the subjects got the answer right for who won the election, only 48.45% answered Task2.20 correctly. The *Majority Criterion* was not mentioned in the learning materials and was a new concept to the subjects at the time of the experiment. It established a situation where pre-existing understanding cannot be taken as a whole to be applied to the new task. Specifically, AV and 'good' voting result were somewhat associated in the learning materials, however, the criteria for voting outcome and its related concepts such as majority, first preference, and preference had to be considered separately from the characteristic of AV to come to the right conclusion for Task2.20.

Task3.S1 presented another problem that requires careful thinking and does not have a straightforward answer. It presented a multi-seat election problem while all learning materials had been exclusively about single-seat election. It also contradicted what was promoted as a nice feature of AV – with AV, one can vote for more than one candidate per seat. With careful thinking, one might consider how his/her vote may decrease the favorite candidates' chance of winning by increasing other candidates' chance, the chance for candidates that the voter does not favor, how one might vote to decrease the chances of candidates who are not desirable. Depending on the level of thinking involved in the answers, a score from 0 to 2 were assigned to each answer (see Table 4-21).

Task2.20 and Task3.S1 were used as dependent variable to test the hypothesis of KT effectiveness. Regression and Pearson's Chi-square test were used, the results were not significant. In fact, in the regression analysis of Task2.20, the coefficient of Prior Knowledge of was significant, and the coefficient of GPA was marginally significant at the 0.06 level.

Task3.S1 was not only correlated with Task3.S2, and not any explanatory variables that were tested.

In summary, hypotheses of the main and interaction effects on knowledge specific cognitive flexibility and knowledge transfer were tested. It was found that the effect of knowledge presentation was influenced by the learners' cognitive style, and possibly their learning style. No significant relationship was found between the cognitive style (CF) and knowledge transfer (KT) performance. Implications of the findings and directions for future research are discussed in the next chapter.

Chapter 6: CONCLUSIONS

In this final chapter, the findings of this study are summarized, and the implications of these findings are discussed. In Section 6.1, the findings are highlighted, and their implications discussed. In Section 6.2, the limitations of this study are discussed. In Section 6.3, directions for future research are suggested.

This study started out with two research questions: (1) What cognitive factor affects the effectiveness of KT? (2) What characteristics of knowledge presentations influence this factor? The answer to the first question provided in this study is the flexible understanding of the knowledge content (FLUKC). The hypothesis tested was H1 which linked the flexible understanding of specific knowledge content (FLUKC) to the effectiveness of knowledge transfer (KT). H1 was not supported by the data collected.

The answer to the second question is a set of knowledge presentation principles that are argued to be helpful in increasing flexible understanding of the knowledge presented. The answer to the second question also addresses how individual cognitive traits interact with knowledge presentation to affect flexible understanding. Hypotheses H2 to H9 were tested (see Table 6-1). Specifically, H2 tested the main effect of Knowledge Presentation on FLUKC; it was not supported. H3 tested the main effect of Learning Style; it was not supported; H4 tested the interaction effect of Learning Style with knowledge presentation on FLUKC; it was not supported at the alpha = 0.05 significant level, but was significant at the 0.10 level. In particular, it was shown that when the knowledge presentation of the learning materials emphasizes flexible understanding, subjects who prefer abstract conceptualizing tend to develop higher level of FLUKC than when the knowledge presentation does not emphasize flexible understanding. On the other hand, when the knowledge presentation of the learning materials does not emphasize flexible understanding, subjects who prefer concrete experiencing tend to develop higher level of FLUKC than when the knowledge presentation does emphasize flexible understanding ($F = 2.477$, Sig. = 0.087). H5 tested the interaction effect of a particular Learning Style (Assimilator) with knowledge presentation on FLUKC; it was not supported.

Hypothesis H6 tested the main effect of cognitive style; it was not supported. H7 tested the interaction effect of cognitive style with knowledge presentation on FLUKC; it was supported at the 0.05 significance level. In particular, it was shown that when the knowledge presentation of the learning materials emphasizes flexible understanding, Innovators tend to develop higher level of FLUKC than when the knowledge presentation does not emphasize flexible understanding. On the other hand, when the knowledge presentation of the learning materials does not emphasize flexible understanding, Adaptors tend to develop higher level of FLUKC than when the knowledge presentation does emphasize flexible understanding. H8 tested the main effect of general intelligence on FLUKC; it was not supported. H9 tested the interaction effect of general intelligence with knowledge presentation on FLUKC; it was not supported. See Table 6-1 for a list of hypotheses and test results. See Figure 6-1 for a graphic presentation of the tested relationships.

Table 6-1. Hypothesis

Hypothesis	***Description***	***Supported***
Hypothesis 1: *More flexible understanding of the knowledge content (FLUKC) leads to more effective KT.*	*Main effect of FLUKC KT*	*No*

Hypothesis 2: *Compared with the single-case control condition, the multi-case treatment condition leads to higher flexible understanding of the knowledge content learned in learning process.*	*Main effect of Knowledge Presentation*	*No*
Hypothesis 3: *Subjects favoring the Abstract Conceptualization mode of learning will develop more flexible understanding of the knowledge content than subjects who prefer the Concrete Experience mode of learning.*	*Main effect of Learning Style*	*No*
Hypothesis 4: *Under the multi-case treatment condition, the differences in FLUKC between subjects who prefer the Abstract Conceptualization mode of learning and subjects who prefer the Concrete Experience mode of learning will be smaller than the differences under the single-case control condition.*	*Interaction effect of Learning Style*	*No*
Hypothesis 5: *Under the multi-case treatment condition, subjects who prefer the Assimilator learning style will develop more flexible understanding of the knowledge content than those who prefer other learning styles.*	*Interaction effect of Learning Style*	*No*
Hypothesis 6: *Innovators on average develop more flexible understanding of the knowledge content than adaptors.*	*Main effect of Cognitive Style*	*No*
Hypothesis 7: *Under the multi-case treatment condition, the differences in FLUKC between innovators and adaptors will be smaller than the differences under the single-case control condition.*	*Interaction effect of Cognitive Style*	*Yes*
Hypothesis 8: *Individuals with high level general intelligence on average develop more flexible understanding of the knowledge content than those with lower level general intelligence.*	*Main effect of General Intelligence*	*No*
Hypothesis 9: *Under the multi-case treatment condition, the differences in FLUKC between high level intelligence individuals and low level intelligence individuals will be smaller than the differences under the single-case control condition.*	*Interaction effect of General Intelligence*	*No*

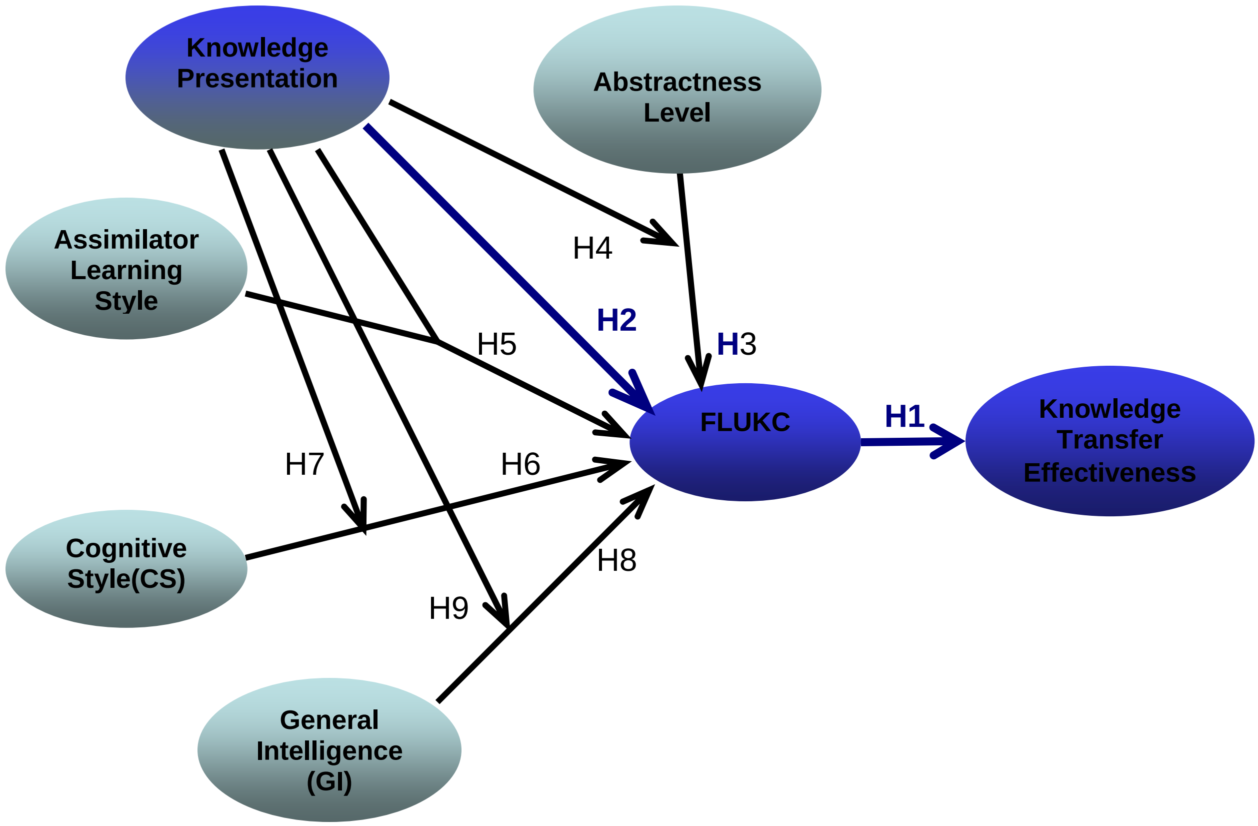


Figure 6-1. Model and Hypothesis

6.1 Findings and Conclusions

It was hypothesized that knowledge presentation affects the flexibility with which one understands the knowledge content, and that this effect is moderated by an individual's cognitive style and learning style. The experimental data provided moderate support for the moderating effect and no support for the main effect of knowledge presentation or individual characteristics.

6.1.1 The Interaction Effect of Cognitive Traits

It was found that the influences on FLUKC of knowledge presentations that emphasize flexible understandings were dependent on the individual's cognitive style, and possibly learning style. Specifically, adaptive learners developed higher FLUKC than the innovative group under the single-case control condition; and the innovative learners developed higher FLUKC than the adaptive group under the multi-case treatment condition. Similarly, the preference for abstract conceptualizing also moderated the impact of knowledge presentations that emphasized flexible understanding. The data displayed similar interaction pattern between the learners' abstract conceptualizing level and the treatment condition, although the statistical tests were not significant at the .05 level. Learners who prefer abstract conceptualizing benefited from the multi-case treatment condition and developed higher FLUKC, while those who prefer concrete thinking seemed to have struggled under the multi-case treatment condition and may have done better under the single-case control condition.

The lack of consistently better result for the treatment condition is consistent with the cognitive fit concept (Vessey 1991). The multi-case knowledge presentation did not help increase FLUKC in all cases, in fact, it seemed to have hindered the development of flexible understanding of the knowledge content for workers who were adaptors or preferred to learn from concrete experience. On the other hand, innovators and knowledge workers who prefer abstract conceptualizing suffered the single-case control condition and developed a less flexible understanding of the knowledge content than the other groups under the same condition. The cognitive fit concept may help to explain this phenomenon. It has been suggested that the fit between learning methods and learning style improves learning outcome (Furnham 1995). Sein and Robey (Sein et al. 1991) found that trainees performed better when training methods used matched their learning styles. For instance, *convergers* and *assimilators* performed better when trained with an abstract conceptual model (depicting the computer system in terms of synthetic forms, e.g., flowcharts or abstract schematic diagrams), whereas *divergers* and *accommodators* performed better when provided with an analogical model (which depicts the computer system in terms of another with which the learner is familiar). Kolb's learning style theory claims that people who have a clear learning style preference will tend to learn more effectively if learning is orientated according to their preference. In addition, there were not enough subjects for every combination to study the three way interaction between cognitive style, learning style, and treatment condition. It might be worthwhile to take all three properties into consideration together.

As mentioned earlier, the interaction effect showed a crossing pattern. There is no unanimous better result for the knowledge presentation. On the contrary, individual cognitive traits such as cognitive style and (possibly) learning style seemed to have dominated the impacts on the development of flexible understanding of the knowledge content. Given same knowledge presentation, those who found the fit the between their cognitive traits and the characteristics of the knowledge presentation excelled, and those who didn't find the fit suffered.

6.1.2 Knowledge Presentation

The factual knowledge test scores for both the treatment group and control group were high, there was no difference in the scores between the two groups. This suggests that both types of knowledge presentations imparted the basic knowledge successfully. When the majority of the subjects had little prior knowledge of approval voting, and of plurality voting either for that matter, they learned the rules and basic application of approval voting using either type of learning materials.

The difference in knowledge presentations did influence flexible understanding, even though there was no dominating effect. The interaction with individual cognitive traits implied that knowledge presentation mattered in developing understandings of the materials that are deeper than basic factual knowledge. This study applied the principles of the Cognitive Flexibility Theory (CFT) in the design of knowledge presentations. The findings confirmed the relevance of knowledge presentation and the dimensions of knowledge presentation included in these principles in the formation of flexible understanding. The findings suggest that the CFG principles help individuals with an Innovator's cognitive style to develop more flexible understandings. The findings also indicate that the CFT principles might help individuals who prefer abstract conceptualizing to develop more flexible understandings, too, although the relationship was significant only at the alpha = 0.10 level.

6.1.3 The Link to Knowledge Transfer

The final topic of interest of the research is that of understanding knowledge transfer. The empirical results did not confirm the link between CF and KT. The measure of KT used in the current study was scores on the problem-solving tasks. In retrospection, the tasks might have been a bit too simple to adequately differentiate KT performance, consequently, the analysis lacked sufficient power to demonstrate the relationship. On the other hand, it might be the measure of CF that lacks reliability. A subsection is attributed to the discussion of alternative CF measures with the collected data in the "Future Research" section.

6.2 Limitations

With no exception, this study has its limitations. The key ones are discussed in this subsection. Some limitations intrinsic to the methodology applied will be discussed first, followed by the ones related to measurement.

6.2.1 Methodology

A laboratory experiment was used to collect the data needed for this research. Laboratory experiments have many advantages, such as the level of control the researcher may have, strong internal validity, relative time efficiency, etc., and these advantages made experiment the chosen method. Nevertheless, an experiment has its disadvantages as a research method (Campbell et al. 1969), which may limit the generalizability of results (Cook et al. 1979). Hence, the findings of this study need to be interpreted with the following in mind.

A main disadvantage of laboratory studies is that they are carried out in controlled and contrived settings, which is different from reality even with careful designs. Even though from the design to the execution of the study, care was taken to make the experiment setting resemble reality as much as possible, the working environment during the experiment differed from a real organizational situation. For instance, the learning process and learning materials were constrained to what was provided under the experimental conditions, whereas in a real KMS setting, a learner might be able to request and choose relevant documentation in different formats, and learn them in any sequence at his or her own pace. In addition, in reality there would likely to be at least some minimum peer pressure for finishing the learning materials and tasks. During the experiment, some subjects might have felt pressured to read, think, or make a decision faster because some peers had already finished. Also, the nature and degree of participant incentives in the experiment tend to differ from those in a real organizational situation. The incentive to get the correct answer or make the right decision in organizations may be much stronger than in the experiment, as it was not required for the participants to give the right answers to earn credit.

6.2.2 Measurement

In retrospection, the problem-solving tasks might not be sophisticated enough to sufficiently differentiate KT performance. The lack of variance in KT performance might have directly contributed to the absence of evidence for the CF to performance link. For instance, almost half (46.9%) of the subjects received the highest score on KT2, and 34.5% received the next highest score, only 6.7% of all subjects received a 0 or 1. KT5 was more spread out, but still 14.9% of the subjects received the highest score, and over half of the subjects received the second and the third highest score. Therefore, it could be that the problem-solving tasks used to measure the KT performance were not able to reflect the levels of performance needed to test the hypotheses.

The measures of CF used in the study are calculated based on the number of voting concepts given by the subject and how he/she grouped the concepts. All concepts and groups are treated indiscriminately in the calculation. As the subjects were at their will to use any voting related concepts, the outcome included a big variety of concepts and groupings. Since the subjects did not work on the same concepts, the comparability among the CF measures of different subjects was reduced. Moreover, the CF measures depend on the difference between the complexity measures of the two grouping steps. This measurement was one of the most time-consuming steps of the experiment; the quality might be less if the subjects lost patience. Given the 'noise' introduced in the measurement, the reliability of the CF measures may have deteriorated. More about CF measures will be discussed in the future research section of this chapter.

The knowledge presentation used in this research was limited to an abstract (such as definitions and rules) description, single case reading material, and multiple-case reading material. Other types of knowledge presentation should be tested in future research to investigate their impact on flexible understanding. Furthermore, the multiple-case learning material inevitably introduced more contextual and application information to the subjects, which may have been a threat to the internal validity of the study.

6.3 Implications for Future Research

6.3.1 Knowledge Presentation and CF

As the findings of this study suggest, different types of knowledge presentations that fit different individual cognitive properties may benefit the understanding and application of knowledge content. This study applied one type of knowledge presentation, cases. Other dimensions of knowledge presentation such as the availability of explanation facilities and order of information presentation (Arnold et al. 2006), a state-based view or an event-based view of organizational data (Allen et al. 2006), and media selection (Massey et al. 2006) may all well affect the learning outcome including the level of flexibility of understanding. A review of knowledge presentation research is necessary to further investigate the issues of knowledge presentations in a knowledge management system. It will be beneficial to investigate the dimensions of knowledge representation and the mechanisms through which they affect cognition.

6.3.2 Learning Style

The empirical findings of this study indicate that there might be an interaction effect between knowledge presentation and learning style. Formal hypothesis testing was conducted for the two extremes on the ***Perception Continuum*** (Kolb 1984) of learning, the result for the interaction effect is significant on the 0.10 level but not on the 0.05 level. In a post-hoc analysis, the ***Processing Continuum*** (Kolb 1984) was considered simultaneously. Specifically, the Converging learning style was compared with non-converging styles; the result was not significant. Future analysis can focus on a finer level of contrast, for instance, comparing the Converging style with the opposite Diverging style. As the Converging and Diverging styles are opposite to each other on both of the two dimensions of learning style (namely, the perception continuum and processing continuum), the chances of observing their effects on the cognitive outcome FLUKC may be larger.

Similarly, analysis can focus on the two extremes of the perception continuum in hoping to increase the chance of discovering a significant relationship between learning style and FLUKC. In the analyses of this study, both the 3-level Abstractness Level analysis and the 2-level Abstractness Level analysis included all subjects who had valid data. These included subjects whose preference for Abstract Conceptualizing (AC) versus Concrete Experiencing (CE) lay in the middle. In other words, these subjects had no strong preference for one type of perception method over the other type. Including only subjects who are at the extremes might sharpen the difference and hence lead to significant results.

In addition, other measures of learning style may be explored to test the relationship. For instance, the widely used personality inventory Myers-Briggs Type Indicator (MBTI) can be administered to assess an individual's preference for taking information. According to MBTI, the two extremes on this mental preference dimension are sensing and intuition. Those who prefer *Sensing Perception* gather information by focusing on facts within information and favor clear, tangible data and information that fits in well with their direct here-and-now experience. In contrast, those who prefer *Intuition Perception* gather information by interpreting patterns, possibilities and meaning from information received and favor more abstract, conceptual, and big-pictured information that represents imaginative possibilities for the future (Myers 1995). The *Intuition Perception* and the related preferred perception on the conceptual level should facilitate a flexible understanding of the knowledge content.

6.3.3 Other Cognitive Traits

This study included two important cognitive traits (learning style and cognitive style). There are other individual traits that play important roles in learning (Gupta et al. 2006). For example, Anxiety is an individual trait that is relevant to this study. Trait Anxiety (TA) has been defined as "(t)he general feeling of anxiety when confronted with problems or challenges" (Thatcher et al. 2002). Thatcher et al. argued that TA tends to have a direct, positive association with domain-specific trait anxiety, which in turn shapes individuals' perceptions of their capabilities (i.e., self-efficacy). It is argued that a strong sense of efficacy helps retain high perception of capability in the presence of difficult problems and thus lead an individual to overcome the obstacle (Compeau et al. 1995). Another cognitive trait is Cognitive Absorption (CA). CA has been defined as a state of deep involvement and as representing a situational intrinsic motivator (Agarwal et al. 2000). Intrinsic motivation may very well affect the performances of cognitive tasks, such as the flexible understanding measurement and problem-solving tasks. Another relevant factor is individuals' reading comprehension, since the learning materials and all tasks materials are all text-based.

6.3.4 Situational Demands

In addition to individual differences, situational demands may also interact with knowledge presentation characteristics and should be considered simultaneously to understand the matter of the formation of flexible understanding. For instance, different tasks (McGrath 1984) might require different levels of knowledge transfer, which in turn, put emphasis on different human and technology properties. Prior studies have conceptualized tasks as 'near-transfer tasks' (Borgman 1986) versus 'far-transfer tasks'(Mayer 1981) in terms how far task requirements part from the task-doers' related experience (Davis et al. 1993; Sein et al. 1989).

6.3.5 Applications in a KMS

The research of individual cognitive traits and knowledge presentation characteristics can be applied in the result processing step of the knowledge discovery services. Ranking is a typically applied technique to sort search results so that the results that mostly likely fulfill the user need are presented first (Maier et al. 2005). The criteria for ranking are critical to finding the most supportive documents. The individual traits and knowledge presentations describe the user properties and knowledge source properties, respectively. The characteristics of knowledge presentation can be added as meta-data of the knowledge source, and users may specify the knowledge presentation type as a criterion of searching or ranking. The ranking algorithm may also use individuals' cognitive traits properties to search for the most suitable result sets. Building on the interaction effect between cognitive style and flexible knowledge presentation discovered in this study, future research should explore the application of this pattern in knowledge management systems. Studies can test the effectiveness of this approach by comparing systems that implement individual traits and knowledge presentation characteristics in ranking the search results and those that do not implement this feature. Based on the findings of this study, systems that match the individual and knowledge presentation properties should provide more satisfactory search result and subsequently, learning outcome.

Another application of the knowledge of individual cognitive traits and knowledge presentation is in personalization in the context of knowledge portal. Knowledge portals employ user-profiling to adapt formerly standardized services to specific needs of individuals (Maier et al. 2005). Future study can compare the effectiveness of systems that match knowledge presentation properties with cognitive traits and those that do not make this effort.

6.3.6 From Flexible Understanding to Effective KT

The goal of this study was to find ways to enhance knowledge transfer. The missing of evidence for this link in the empirical findings should be treated with caution. Readers are warned that rather than being viewed as a proof of the lack of this causal link, the result should be regarded as a call for new and deeper investigation of matters such as measurement and moderating factors and other relevant issues.

6.3.7 CF Measurement

The lack of support for the link between CF and KT may have been caused by the lack of reliability in the measure of CF. With the current method used to gauge CF, H (absolute complexity) may increases, decrease, or although rarely, remains the same as a result of the second grouping. No change in grouping is associated with low level of CF because it is assumed that one lacks the ability to modify the original grouping as he/she rigidly adheres to his/her initial concept system. An increase in H is associated with high level of CF because gains in H can only result from selectively reorganizing the grouping. A decrease in H is conditionally associated with low CF. Specifically, if the decrease in H results from adding the newly identified concepts to every group, then it is considered a complete breakdown of the original conceptual system and associated with low CF; if the decrease in H results from selectively regrouping the concepts, then the measure becomes unexplainable.

In investigating individual results, the following situations were found to make the analysis difficult. First, some subjects grouped only the concepts in the given list in the second step and left out the concepts in the first step. This is further complicated by categories used in the second step: some subjects partially used the categories in the first step, some added new categories to the old categories, yet some completely abandoned the old categories and used only new categories.

Based on the aforementioned discovery, concepts and groups that were used in the first step but not in the second step were recovered conditionally.

In the recovering process, we gave a score that is potentially related to the cognitive flexibility of the subject. The score is named Degree of Regrouping, and as the name suggests, it reflects the degree of regrouping. Several aspects related to regrouping in the second step were considered, namely, (1) if the old groups are kept in the regrouping, and if yes, are all the groups kept or only some groups kept, (2) if there are any new groups added, and (3) are old concepts and new concepts mixed in the groups or kept separate. The scoring is based on the following beliefs:

higher flexibility tends to lead to regrouping that may manifest as: keeping at least some old groups rather than abandoning them all; adding some new groups; and mixing the concepts in the groups as apposed to keeping them separate in different groups. A scheme for the Degree of Regrouping score was developed (Table 6-2).

Table 6-2 Degree of Regrouping

Type I	***Used Only Old Group***	***Criteria***
	Used ALL Old Groups	
A11		*1. New concepts mixed with old concepts. Leave as is.*
A12		*2. Old concepts only (this is equal to no regrouping, hence may not exist in data). Leave as is.*
A11		*3. New concepts only. In this case, old concepts that were in the group should be added back, as the absence of the old concepts may simply be omission for the sake of time.*
	Used SOME Old Groups – Should all old groups be added back? Yes, because in this case the old groups might be omitted if no new concepts are added to them.	
A21		*1. New concepts mixed with old concepts. Leave as is.*
A22		*2. Old concepts only (this is equal to no regrouping, hence may not exist in data). Leave as is.*
A21		*3. New concepts only. In this case, old concepts that were in the group should be added back, as the absence of the old concepts may simply be omission for the sake of time.*
Type II	***Used Only New Group***	
B1		*1. New concepts mixed with old concepts. Leave as is.*
B2		*2. Old concepts only. Leave as is.*
B3		*3. New concepts only. Leave as is.*
	Should the old groups be added? - Judgment call - are the new groups replacement of the old groups?	*If old groups are added, then this category becomes Type III; if replacement of old group, then regrouping degree is high;*
Type III	***Used both New and Old Groups***	
	Used ALL Old Groups	

C11		*1. New concepts mixed with old concepts. Leave as is.*
C12		*2. Old concepts only (this is equal to no regrouping, hence may not exist in data). Leave as is.*
C11		*3. New concepts only in old group. In this case old concepts that were in the group should be added back, as the absence of the old concepts may simply be omission for the sake of time.*
C12		*4. New concepts only in new group. Leave as is.*
	Used SOME Old Groups – Should all old groups be added back? Judgment call - are the new groups replacement of the old groups?	*If old groups are added, then this category becomes Type C12; if replacement of old group, then regrouping degree is high;*
C21		*1. New concepts mixed with old concepts. Leave as is.*
C22		*2. Old concepts only (this is equal to no regrouping, hence may not exist in data). Leave as is.*
C21		*3. New concepts only in old group. In this case, old concepts that were in the group should be added back, as the absence of the old concepts may simply be omission for the sake of time.*
C22		*4. New concepts only in new group. Leave as is.*

Added new groups should be treated discriminately. If new groups are added in addition to putting new concepts to old groups or mixing old and new concepts in the new group, then this is considered as additional regrouping and should be associated with higher CF. If any new groups are added without putting new concepts into old groups or mixing old and new concepts in a new group, in other words, at least one new group is created for just new concepts, then it can be considered as a sign of failure to mix old and new concepts; consequently, it should contribute negatively to the degree of regrouping.

The regrouping strategy should be supported by some literature on CF measurement. Then the revised measure needs to be used to re-test the hypotheses replacing CF measures used in the current analysis.

6.4 Implications for Practice

Knowledge is becoming increasingly important to gaining and maintaining competitive advantage for businesses in the time of modern commerce. The successful reuse of precious knowledge assets depends on effective knowledge management. Lessons that can be drawn from this study for the KM practice are three-fold. First, when a flexible understanding of the problems and solutions are required in an organizational environment in a lot of situations, careful design of knowledge presentations in a KMS system may increase its effectiveness. The principles of CFT emphasize multiple presentations of the knowledge content, promote the interconnection of knowledge pieces, advocate knowledge reconstruction as opposed to intact retrieval of rigid knowledge chunks, and warn against oversimplification of the knowledge content. Designers of knowledge presentations in an organizational environment, such as in a Knowledge Management System, should consider these principles and their impacts, including the interactions with the cognitive traits of individual knowledge workers.

Second, knowledge management needs to consider individual cognitive traits such as cognitive style as they tend to moderate the cognitive outcome of learning. Our findings suggest that not all individuals benefit from more flexible knowledge presentations. In fact, when an individual's cognitive style fits the characteristics of the knowledge presentation, he/she tends to develop more flexible understanding of the knowledge content to be conveyed. This interaction pattern suggests that matching both properties may produce superior outcome. Moreover, cognitive traits are persistent across time and situations. Therefore, it may be more effectual to manipulate knowledge presentation characteristics to fit individual needs than the other way round. It is common for Human Resources to build profiles of employee personality, which are closely related to learning and cognitive styles. This information about individual knowledge workers should be applied in the provision of knowledge services.

Third, the empirical results of this study suggest that not all knowledge workers benefit from knowledge presentations designed to nurture flexible understandings. The implication to practice is that, as far as developing flexible understanding of certain knowledge is concerned, individual learning and cognitive styles must be considered in that they may require different types of knowledge presentations. The guidance for knowledge management system (KMS) design is to create multiple types of presentations for the same knowledge content; and make it easy for the knowledge workers to choose the ones that meet their needs or the situational demands. Also, developing matching mechanisms (such as ranking) to use in the processing of search results should improve the quality of knowledge services.

6.5 Summary and Concluding Remarks

The effective application of existing knowledge to solve new problems is a central issue of knowledge management, and increasingly, the center of competition in modern economy. The very nature of knowledge makes its application very challenging, especially in situations where knowledge workers need to re-assess the requirement and re-organize the knowledge components in reaction to changed requirements. These knowledge transfer issues are what have motivated this study.

An examination of the learning and cognitive education literature leads us to the cognitive flexibility concept which is hypothesized to affect knowledge transfer. Bostrom's (1990) learning framework was applied to identify factors that affect cognitive flexibility. Knowledge presentation is an aspect that can be designed to affect learning outcome. In the form of stories, cases provide rich contexts needed for a deep understanding of the knowledge enmeshed within. Both the Cognitive Flexibility Theory (CFT) and the learning and educational psychology literature suggest that a flexible understanding is necessary for effective Knowledge Transfer (KT), which is defined as the application of knowledge in new problem settings and the subsequent adjustments needed in response to changed requirements.

CFT suggests that the learning process and materials can be created with flexible understanding in mind, and that learners will gain a more flexible understanding of the materials as a consequence of going through such a learning process than they would using rigid learning materials and processes. CFT also suggests several principles to build in CF in the learning material. The focus of CFT is case-based reading materials, which is recommended for its capability of providing multiple contexts and showing the interconnections of related knowledge aspects. Case-based Reasoning (CBR) (Kolodner 1997) is another theory that advocates the use of cases in learning. It argues that by using cases, the learners are exposed to the process of applying what is to be learned, the details of making choices and decisions, and the consequences and recovery of making mistakes. All these reasoning contribute strongly to knowledge construction, which is critical to knowledge transfer.

Based on these theories, a set of learning cases were created with the intention to provide multiple contexts and the interconnection of them. These cases were used under the treatment condition. A control condition was created which involved a single case that applied the same subject knowledge in a single context. Both the control case and the multiple cases for the treatment condition can be found in Appendix A.

A lab experiment was used to collect the data from 194 undergraduate students. Due to missing and invalid data, the analysis used the data from 184 subjects. The subjects were randomly assigned to either the treatment group or the control group. The knowledge presentation for the treatment group implemented the CFT principles, emphasizing flexible understanding of the knowledge content, while the knowledge representation for the control group did not focus on flexible understanding. The flexibility with which a subject understands the knowledge content was tested. KT was measured in the form of problem-solving. The link between knowledge presentation and flexible understanding, as well as the link between flexible understanding and KT were tested. Linear Regression, MANCOVA, and ANCOVA were used to test the hypotheses. Three control factors were identified to account for cognitive individual differences that might confound the effects. These factors are Cognitive Style, Learning Style, and General Intelligence. These factors were tested and used in the analysis.

The empirical findings confirmed the presence of the effect of knowledge presentations, however, this effect is shown to be affected by an individual's cognitive style. The findings also implied similar effect of learning style, although the effect was not significant. There was not enough evidence of the causal link between flexible understanding of the knowledge content and KT.

The findings and their implications were discussed earlier in this chapter. This study contributes to the existing knowledge of knowledge management from several aspects. First, the study addressed two critical and related challenges in knowledge management – the maintaining and transfer (as in the sense of application) of existing knowledge. Because knowledge is embedded within contexts, and contexts are difficult to document as they tend to be broad, dynamic (Argote et al. 2000b), socially held and ambiguous (Szulanski 2000), capturing, maintaining, and reusing of the knowledge are hard. Our study suggests that knowledge presentation provides a way to help capture the tacit part of knowledge that is critical to understanding, and consequently, to knowledge application. Two, this study integrated the research of knowledge transfer with that of learning and educational psychology, and confirmed the effectiveness of some knowledge presentation principles in affecting the development of a flexible understanding of the knowledge to be conveyed. This finding suggests that knowledge presentation offers a feasible means to develop flexible understanding of the knowledge to be transferred. Three, the study confirmed the importance of individual cognitive traits (cognitive style and possibly learning style) in affecting the formation of a flexible understanding. It also suggests that the fit between individual cognitive traits and the characteristics of knowledge presentation dominates any solitary effect either the cognitive trait or knowledge presentation. Therefore, one should take individual traits into consideration when designing knowledge presentations.

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A.1 Learning Materials – Abstract Description

Abstract Presentation (common to both groups)

Part 1. Definition and Rules of AV:

• Approval voting (AV) is a voting procedure in which voters can vote for, or approve of, as many candidates as they like in multi-candidate elections (i.e., those with more than two candidates). Each candidate approved of receives one vote, and the candidate with the most votes wins.

• In single winner (election for a single seat) Plurality Voting (PV), each voter is allowed to vote for only one candidate, and the winner of the election is whichever candidate represents a plurality of voters, that is, whoever received the largest number of votes. If n people are to be elected, then each voter votes for at most n candidates, the n candidates with the most votes win. Unlike PV, which allows a voter to select only one candidate for each seat, Approval Voting is a voting system in which each voter can vote for as many or as few candidates as the voter chooses. Each voter may vote for as many options (or candidates) as he or she chooses, at most once per option (or candidate). This is equivalent to saying that each voter may "approve" or "disapprove" each option (or candidate) by voting or not voting for it. The votes for each option are tallied. For a single-position election, the option (or candidate) with the most votes wins; for multiple-position election, the options (or candidates) with the most votes win.

Part 2. Some Impacts of AV

1. **Voter's Point of View** Approval Voting may be viewed as an extension of plurality voting that allows voters to express their preferences more fully in multi-candidate elections. They can do everything they can under PV—vote for a single favorite—but if they have no strong preference for one candidate, they can express this fact by voting for all candidates they find acceptable. In addition, if a voter's most-preferred candidate has little chance of winning, then that voter can vote for both a first choice and a more viable candidate without worrying about wasting his or her vote on the less popular candidate.

2. **Candidate's Point of View** AV will give minority candidates their proper due, hence provide a more complete measurement of electorate support for each candidate. Minority candidates will not suffer under AV: their supporters will not be torn away simply because there is another candidate who, though less appealing to them, is generally considered a stronger contender. Because AV allows these supporters to vote for both candidates, they will not be tempted to desert the one who is weak in the polls, as under PV. Hence, minority candidates will receive their true level of support under AV, even if they cannot win. This will make election returns a better reflection of the overall acceptability of candidates, relatively undistorted by strategic voting, which is important information often denied to voters today.

3. **Outcome Point of View** Under AV, the candidate with the greatest overall support will generally win. Under PV, by contrast, the candidate supported by the largest group often wins, even when the largest group does not reach the majority (more than 50%) of the whole. In particular, *Condorcet* candidates, who can defeat every other candidate in separate pairwise contests, almost always win under AV, whereas under PV they often lose because they split the vote with one or more other centrist candidates.

4. **AV and tactical voting**. PV is vulnerable to tactical voting, or strategic voting, whereby a voter misrepresents his or her sincere preferences in order to gain a more favorable outcome. For instance, a voter may switch to a second choice if his or her first choice does not appear to have a big chance to win, as indicated, for example, by polls. While AV encourages sincere voting – voting for all candidates above the lowest-ranked candidate one considers acceptable – it does not eliminate strategic calculations altogether. Because approval of a less-preferred candidate can hurt a more-preferred candidate, the voter still faces the decision under AV of where to draw the line between acceptable and non-acceptable candidates.

A.2 Treatment Group Cases (1 ~3)

Case 1. School Class President

Consider the election for the president of a school class that uses the **PV** systems. In our hypothetical election, there are 40 voters, 16 boys and 24 girls, and three candidates: Amy (girl), Brian (boy) and Cathy (girl). Each voter gets a *ballot*, with the name of the three candidates on it. Each voter must put a check mark "X" by the name of the candidate which they want to elect as the president of the class. Each voter may check **one and only one** of the names on their ballot. Further assume that, in this imaginary school, male and female students disagree with each other on most issues, and students prefer to vote for a candidate of the same sex as themselves.

After the election finishes, the papers are sorted into three piles – one for votes for Amy, one for votes for Brian, and one for votes for Cathy. The largest pile decides the winner. The result is as follows:

- Amy 11 votes
- Brian 16 votes
- Cathy 13 votes

Brian wins. Notice that there were a total of 40 votes cast, and the winner had only 16 of them (the boys' votes) – only 40%. Although there are more girls than boys among the voters, the boy candidate wins the election.

Comments:

This comment addresses the case from the election outcome perspective. **The third-party spoiler effect:** some might argue that a boy won for this class because there were two girls, who "split the vote;" some of the girls in the class voted for Amy and others for Cathy. Perhaps if Amy had not been a candidate, *all* the girls would have voted for Cathy and she would have won this class. Arguments exactly like this, but on a larger scale, are common wherever there are plurality elections.

Questions:

Tactical voting, or strategic voting, occurs when a voter misrepresents his or her sincere preferences in order to gain a more favorable outcome. This case is relevant to tactical voting. Think for a moment how an 'Amy-supporter,' a girl in this hypothetical case, can vote to maximize her benefit from the election. How would that affect Amy's votes? If AV instead of PV is used, how would an 'Amy-supporter' vote differently?

Case 2. Bush-Gore-Nader 2000 Florida Race

Nearly all political elections in the United States are plurality votes, in which each voter selects a single candidate, and the candidate with the most votes wins. The plurality system looks only at a voter's top choice. In races with two strong candidates, plurality voting is vulnerable to the third-party spoiler – a weaker candidate who splits some of the vote with one of the major candidates. For instance, in the hotly contested 2000 U.S. presidential race, Republican George W. Bush won the state of Florida – and, consequently, the presidency – by just a few hundred votes over Al Gore, the Democratic candidate. Green Party candidate Ralph Nader won 95,000 votes in Florida, and polls suggest that for most Nader voters, Gore was their second choice. Thus, if the race had been a head-to-head contest between Bush and Gore, Florida voters might have chosen Gore, and possibly by tens of thousands of votes.

Comments:

This comment addresses the case from the voter's perspective. Should Nader have withdrawn from the race, as many angry Democrats asserted? Certainly not, says mathematician Donald Saari of the University of California, Irvine. "We live in a democracy, and anyone should be able to run for any office," he says. "The problem was the bad design of the election." On the other hand, Approval Voting would have enabled Nader supporters to vote for him and also for one or both of the two stronger contenders who they approve of. However, under PV, the voters were forced to choose their top candidate.

Questions:

Assuming that the statement "for most Nader voters, Gore was their second choice" is correct, and that some Nader-voters would have voted for Gore as well as Nader, how could the result for the 2002 Florida presidential election be different had AV been used rather than PV?

Case 3. TIMS 1985

The Institute of Management Sciences (TIMS), an international professional society in the field of operations research, did an experiment to compare approval voting with regular plurality voting in 1985. In the experiment, one person was to be elected from three candidates. Two ballots were used. An official plurality ballot determined the results of the election and an experimental ballot assessed the effects of approval voting. The votes under both PV and AV for this three-way race to elect one person are listed in the following table.

		PV Vote	AV Vote
Candidate	A	386	635
	B	551	801
	C	599 *	871 *
Total Votes		1536	2307
			(1536 voters)

* Largest vote.

In this experiment, plurality and approval votes agree on candidate C. The winning plurality is 39.0% (599 votes divided by 1536 votes), well below 50%. A hypothetical analysis shows that even though candidate C easily wins both plurality and approval votes, C may not be a clear majority candidate (i.e., one who has the broadest support) because it is estimated that A's supporters tend to prefer B to C (information that is not shown in the table). However, on the approval votes, it turns out that among people who voted for A in the plurality election, more approve of C and B (different from the hypothetical estimation). Furthermore, more B-voters approve of C than C-voters approve of B. Thus, C has a 56.7% (871 approval votes divided by 1536 voters) approval count, comfortably over 50% of the voters. Hence, even though C won with only a 39% plurality, AV shows that C was approved of by a majority of the voters.

Comments:

This comment addresses the case from the candidate's perspective. By PV alone, C is not a clear majority candidate because by analysis, we cannot be sure that C would beat B in a two-way race, although we do estimate a slight edge for C. This election demonstrates an attractive feature of AV for three-candidate contests in which all candidates make good showings (i.e., having broad support). From the point of view of plurality voting, C wins because A is a spoiler who takes enough votes away from B to let C carry the day. C's victor in approval voting has a different basis, one that seems better by our criterion of broadest support.

Questions:

In terms of the election outcome, does AV select the candidate with the widest support? Did AV allow the voters to express their view more fully than PV in this case?

A.3 Control Group Case

TIMS 1985 AV Election

The Institute of Management Sciences (TIMS), an international professional society in the field of operations research, did an election under Plurality Voting to elect one person out of three candidates (A, B, and C) for an open seat of a committee. To compare with Approval Voting, the voters were asked to vote for the same seat among the same candidate under Approval Voting as well. In addition, for the purpose of analysis, the voters were asked to rank the three candidates in terms of their preference.

Number of Votes under PV and AV

	Candidates	PV Votes	AV Votes
	A	166	486
	B	827	1224 *
	C	835 *	1054
Total Votes		1828	2764
Number of Voters		1828	1828

* Largest vote

The table above shows the outcome of two elections under PV and AV, respectively. Note that PV and AV produces different winner. Candidate C wins the PV election, by only 8 votes (835 vs. 827), or 0.4 percent (8 divided by 1828 votes). B wins under AV, by a substantial 170 votes, or 6.1 percent (170 divided by 2764 votes). Which result is better?
A ‘better’ result can be defined from a different angle – being more *acceptable* to the voters. The fact that C edges out B in presumed first choices, based on the PV totals, does not mean that C would hold his or her lead if the election was under AV. To analyze this, the preferences for B vs. C of the 166 A voters were taken into account. In fact, the preferences of the 166 voters who voted for A under PV and the number of people in each preference group are as follow:

(1) 70 people ranked the three candidates from the highest to lowest preference in the order of A, then B, then C;

(2) 66 people ranked them in the order of A, then C, then B;

(3) 3 provided no rankings but approved both A and B;

(4) 27 made no distinction between B and C.

In the B-versus-C comparison, it is reasonable to credit group (1) and group (3) to candidate B (70+3 = 73 votes), credit group (2) to candidate C (66 votes), and group (4) to neither candidate. When added to the PV totals, these credits give C (901 votes) exactly one more vote than B (900 votes). However, assuming the 27 voters in (4) split their votes between B and C in the pattern of the 139 voters (70 + 66 + 3) who ranked A first and also expressed a preference between B and C, B would pick up an additional vote (rounded to the nearest vote), resulting in a 914-914 tie.

One hundred and seventy more voters approved of B rather than C in AV, albeit C won the PV contest by 8 votes. The reason for this discrepancy between the AV and PV results is that whereas C has slightly more *stalwart* supporters (i.e., those who vote only for one candidate) than B, supporters of the third candidate, A, more approve of B than C (36 percent to 23 percent). Furthermore, because more of C's supporters approve of B than B's do of C, B would have won handily under AV.

Comments:

In this election, candidate C wins under PV by a small amount, 0.4%, but B would have won under AV by 6.1%, and a head-to-head election would be too close to call. The picture emerges that C has a loyal following that is just a little larger than B's. However, among A's followers, more approve of B than C. Furthermore more of C's followers approve of B than B's followers do of C. Hence AV picks a clear winner, B, on the basis of second choices. These show that B has a broader acceptance in the electorate than C. Therefore, the approval process, by eliciting more information from the voters, leads to the election of the candidate with the widest support.

B.1 Factual Knowledge Test

1. In a ‘six pick one’ election using Approval Voting, what is the maximum number of candidate a voter can vote for?

    a. 1

    b. 2

    c. 3

    d. 4

    e. 6

2. In a ‘six pick one’ election using Plurality Voting, what is maximum number of candidate a voter can vote for?

    a. 1

    b. 2

    c. 3

    d. 4

    e. 6

3. Imagine that the population of Tennessee, a state in the United States, is voting on the location of its capital. The candidates for the capital are: Memphis, Nashville, Knoxville, and Chattanooga. Given the following vote counts under AV, which city wins the election?

City	**Memphis**	**Nashville**	**Chattanooga**	**Knoxville**
Approval Vote	42	68	58	32

    a. Memphis

    b. Nashville

    c. Chattanooga

    d. Knoxville

4. In a ‘six pick two’ election using Approval Voting, what is the maximum number of candidate a voter can vote for?

    a. 2

    b. 3

    c. 4

    d. 5

    e. 6

5. In a ‘six pick two’ election using Plurality Voting, what is maximum number of candidate a voter can vote for?

    a. 2

    b. 3

    c. 4

    d. 5

    e. 6

B.2 CF Measurement

Base on your knowledge about voting (including AV), provide a list of voting related concepts (such as vote for, candidate, voter, election, seat, majority, winner, lose out, etc.), and then group them in multiple groups so that each grouping makes unique sense to you. To understand how it works, look at the following example using food related concepts:

Check	Concepts
✓	1. apple
✓	2. peanut
✓	3. fish
	4. jelly
✓	5. whole milk
✓	6. non-fat milk
✓	7. tomato
✓	8. cabbage
✓	9. pear
✓	10. walnut
✓	11. steak
✓	12. cheese
✓	13. bread
✓	14. spaghetti
✓	15. cucumber
✓	16. chicken egg

Group	Group Name	Items
A.	Grain	13, 14
B.	Veggie	7, 8, 15
C.	Meat	11
D.	Protein	2, 3, 5, 6, 10,
E.	Fruit	1, 7, 9
F.	Fat	2, 5, 10, 12

In the example above, note how concepts (or objects) in the list on the left are grouped into categories A, B, C, D, E, F on the right. The concepts on the left are represented by their associated number in the groups on the right. For instance, “bread” and “spaghetti” are represented by “13” and “14” respectively on the right in group A “Grain”. Note that the groups are NOT mutually exclusive, which means concepts in groups can overlap. Note that some concepts appear in multiple groups, e.g., whole milk (concept 5) is listed in both “Protein” and “Fat”. Note some concepts do not make to any group, such as jelly (concept 4). In fact, it can be listed in its own group, which will have only one item.

Follow the example on previous page, make a list of **voting-related** concepts (such as votes, candidate) and group them. You may: (1) list as many **voting-related concepts** as you want, (2) group them in any way you want (try to name the groups), make as many groups as you want, and (3) put a concept in as many groups as they belong (though in the list on the left you only list each concept once). Check the concept when it is put in at least one group. Be sure to use the number beside the concept (and not the concept itself) in the grouping. Use reverse if you have more concepts or groups.

Check	Concepts
	1.
	2.
	3.
	4.
	5.
	6.
	7.
	8.
	9.
	10.
	11.
	12.
	13.
	14.
	15.
	16.
	17.
	18.
	19.
	20.

Group	Items
A.	
B.	
C.	
D.	
E.	
F.	
G.	
H.	
I.	

Finish the requirements below. **DO NOT GO BACK TO CHANGE YOUR ORIGINAL LIST OR GROUPING!**

A. Are there any concepts in the following list that are not in your original list? Circle them in the table below.

101. approve	102. representation	103. support	104. minority
105. seat	106. candidate	107. spoiler	108. plurality
109. overall support	110. centrist candidate	111. pairwise contest	112. sincere preference
113. polls	114. largest group	115. preference	116. outcome
117. criteria	118. strategic voting	119. withdraw	120. determine

B. Are there any concepts that are neither in the list above NOR in your original list, and you would add to your list? Write them below (add more if you need to).

201.	202.
203.	204.
205.	206.
207.	208.

Regroup all concepts, including the concepts in your original list and the newly identified concepts in step A and B. You can update the groups you made before, add new groups, or completely regroup the concepts. Make as many groups as you wish, put the concepts in all groups they belong, and name the groups. Regroup on the next page.

Regroup your original list of concepts and the newly added ones below

Group	Items
A.	
B.	
C.	
D.	
E.	
F.	
G.	
H.	
I.	
J.	
K.	
L.	

B.3 Problem-solving Task

Task 1. Choose your dessert for a party

Twenty people are making a choice for one ice cream flavor that will be served at a party. A single flavor choice is to be made among chocolate, strawberry, and vanilla. The flavor preferences of the 20 people are shown in Table 1. Seven people prefer chocolate first, vanilla second, and strawberry third; eight prefer strawberry first, chocolate second, and vanilla third; and five prefer vanilla first, strawberry second, and chocolate third. Approval Voting is used to decide the ice cream flavor to serve at the party. Assuming that each person would accept his/her own first two preferences but not the third, and will vote that way, which flavor will be chosen as the result of the voting?

Table 1. Flavor Preferences

Preference	***1st***	***2nd***	***3rd***
Group 1 (7 people)	*chocolate*	*vanilla*	*strawberry*
Group 2 (8 people)	*strawberry*	*chocolate*	*vanilla*
Group 3 (5 people)	*vanilla*	*strawberry*	*chocolate*

15.

Which flavor will be chosen as the result of the voting? Choose your answer by picking out the winner and penciling in its representing letter (A, B, or C) on the scantron sheet. (For instance, if your answer is Strawberry, then pencil in B on the scantron sheet.)

A. Chocolate
B. Strawberry
C. Vanilla

16.

Suppose three people of Group 2 (the strawberry-chocolate-vanilla preference group) strongly prefer strawberry, and they want to use their votes to maximize the chance that strawberry is chosen. Suppose that you are one of these three people, how can you vote to maximize the chance that strawberry is chosen? Use the scantron sheet to cast your vote by penciling in your choice(s).

A. Chocolate
B. Strawberry
C. Vanilla

Task 2. The Majority Criterion

<u>Majority Criterion</u> The Majority Criterion states that if a majority (i.e., more than half of voters) strictly prefers a given candidate to every other candidate, that is, a given candidate is the first preference of more than half the voters, and the voters vote sincerely, then that candidate should win.

For example, in an election with 100 voters and three candidates A, B, and C, 55 voters prefer the three candidates in the order of A, B, then C, 35 voters prefer the candidates in the order of B, C, then A and 10 voters prefer the candidates in the order of C, B, then A (see the preferences in Table 2a). If one person is to be elected, the Majority Criterion dictates that A win the election, because a majority of the voters (55 out of 100) prefers A.

Table 2a. Preferences of the Voters

Preference	**1st**	**2nd**	**3rd**
Group 1 (55 Voters)	A	B	C
Group 2 (35 Voters)	B	C	A
Group 3 (10 Voters)	C	B	A

17.

In the election example above, suppose one person out of the three candidates (A, B, and C) is to be elected **using Plurality Voting**, then who wins the election? Choose your answer by penciling in the representing letter (A, B, or C) on the scantron sheet.

A. A wins.
B. B wins.
C. C wins.

18.

Does Plurality Voting satisfy the <u>Majority Criterion</u> in the above case? Choose your answer by penciling in the representing letter (A or B) on the scantron sheet.

A. Yes
B. No

Suppose the election uses Approval Voting. The results of the election are summarized in Table 2b. Out of the 55 Group 1 voters (preference order A, B, C), 35 approve only candidate A and 20 approve both candidates A and B; all 35 Group 2 voters (preference order B, C, A) approve only candidate B; the 10 Group 3 voters (preference order C, B, A) approve candidates C and B.

Table 2b. Summary of AV Voting Results

	Candidate			
	A		**B**	**C**
Voters				
Group 1 (55 Voters)	35	20	20	
Group 2 (35 Voters)			35	
Group 3 (10 Voters)			10	10

19.

Given the above election outcome, who wins the election? Choose your answer by penciling in the representing letter (A, B, or C) on the scantron sheet.

A. A wins.
B. B wins.
C. C wins.

20.

In the scenario in Question 5, does AV satisfy the majority criterion? Choose your answer by penciling in the representing letter (A or B) on the scantron sheet.

A. Yes
B. No

Analysis

Under Plurality Voting, who wins the election? (Answer: A) Does PV satisfy the *Majority Criterion* in this case? (Answer: yes.)

Under the above Approval Voting result, who wins the election? (Answer: B) Does AV pass the majority criterion in this case? (Answer: no) No, in this case AV does not satisfy the Majority criteria. A majority of the voters prefers candidate A to all other candidates but candidate B wins the election.

Answer:

Candidate	A	B (✓)	C
AV votes	55	65	10

Task 3 Board Election (Scenario 1)

A committee board of eight seats is in charge of decision making for an Internet community – MITRAX. This year two board members are retiring, vacating two seats. Members of MITRAX are having an election to elect two out of seven candidates to serve on the board, along with the six remaining board members. The election uses Approval Voting.

You, as a member of MITRAX, are taking part in the election. You know all 7 candidates well enough to evaluate them as candidates for the seats. Your preference levels of the 7 candidates on a 10-point scale (with 10 being the most favorite and 1 the least) are as follows:

Candidat	Alan	Bill	Cathy	Dave	Ed	Fran	Grace
Preferenc	**1**	**1**	**4**	**10**	**1**	**4**	**6**

You understand that other voters may have different preferences than yours. To ensure that your vote has the maximum impact, you must cast your vote carefully. Use your knowledge of Approval Voting, cast your vote on the Ballot below.

Vote for a candidate by checking the box beside his/her name:	
Alan	☐
Bill	☐
Cathy	☐
Dave	☐
Ed	☐
Fran	☐
Grace	☐

Give the reason why you voted so:

Task 3 Scenario 2

Suppose that for some reason Grace has to withdraw from the election, and that the two board members will be elected from the six remaining candidates. And your preference remains the same as before as follows:

Candidat	Alan	Bill	Cathy	Dave	Ed	Fran	~~Grace~~
Preferen	**1**	**1**	**4**	**10**	**1**	**4**	~~**6**~~

You understand that other voters may have different preferences than yours. To ensure that your vote has the maximum impact, you must cast your vote carefully. Use your knowledge of Approval Voting, cast your vote on the Ballot below.

Approval Voting Ballot (Scenario 2)

Vote for a candidate by checking the box beside his/her name:	
Alan	☐
Bill	☐
Cathy	☐
Dave	☐
Ed	☐
Fran	☐

Please write down your stopping time: ____________________________

Give the reason why you voted so: ____

C. Consent Form

CONSENT FORM

I agree to take part in a research study entitled " Enhancing Knowledge Transfer through Nurturing Cognitive Flexibility", which is conducted by Hui Wang (706-542-4653) under the direction of Dr. Jay E. Aronson (706-542-0991) at the Department of Management Information Systems of the Terry College of Business at The University of Georgia. The objective of this experiment is to investigate how flexible knowledge representations affect learning outcome. I understand that my participation is voluntary; I can stop taking part without giving any reason, and without penalty. I can ask to have information related to me returned to me, removed from the research records, or destroyed.

I will gain one credit point for the MIST2090 class I am currently enrolled in by participating in the experiment. The experiment is approximately 1 hour in length. I will do the following things:

- Report to the experiment location (a classroom) at the time designated by the researcher.
- Read a set of learning materials to learn a particular set of problem-solving knowledge.
- Apply what I learned to solve some problems.
- Fill out questionnaires about my cognitive preferences and personal information which takes approximately 5 minutes to complete.

I understand that no discomforts or stresses are expected and no current or future risks are expected.

I understand that I will be assigned an identifying number and this number will be used on all of the questionnaires I fill out. No individually identifying information about me or provided by me during this research will be shared with others without my written permission, except if required by law.

The researchers will answer any further questions about the research, now or during the course of the project and can be reached by the telephone numbers listed above.

I understand the procedures described above. I am agreeing by my signature on this form to take part in this research project and understand that I will receive a signed copy of this consent form for my records.

_______Hui Wang____	__________________________	___________
Name of Researcher	Signature	Date
Telephone: __706.542.4653__		
Email: ____huiwang@uga.edu_____		

____________________________	__________________________	___________
Name of Participant	Signature	Date

Please sign both copies, keep one and return one to the researcher.

D. Pre-learning Questionnaire

The following questions are about your experience of voting and elections.

1. Are you a U.S. citizen?
    a. Yes
    b. No
2. If not, what country are you a citizen of? Answer: ___________________________
3. In your country, are you a registered voter?
    a. Yes
    b. No
4. How often do you vote for government election?
    a. Never
    b. About half of the time
    c. About every time
5. Have you ever taken part in government election?
    a. Yes
    b. No
6. Have your ever been involved in any type of voting situations for any purposes (such as electing a Prom Queen, or a location for a celebration party)?
    a. Yes
    b. No
7. Have you heard of Plurality Voting?
    a. Yes
    b. No

8. You have ___________ knowledge of Plurality Voting.

    a. zero
    b. a little
    c. some
    d. pretty good
    e. a lot of

9. Have you heard of Approval Voting?

    a. Yes
    b. No

10. You have ___________ knowledge of Approval Voting.

    a. zero
    b. a little
    c. some
    d. pretty good
    e. a lot of

11. What does “runoff” mean?

____

____

____

____

E. Post-experiment Questionnaire

We'd like to know your satisfaction about the learning and tasks in the experiment. **Pencil in the answer to the following questions on the Scantron sheet.**

1. How do you feel about the learning process in the experiment?
    a. Very unsatisfied
    b. Unsatisfied
    c. Neutral
    d. Satisfied
    e. Very satisfied
2. Did you find the learning case(s) provide enough contexts to help understand the rule and impact of Approval Voting?
    a. No. The contexts in the case(s) were way too little.
    b. No. The contexts in the case(s) were limited.
    c. It's all right.
    d. Yes, the contexts in the case(s) were enough.
    e. Yes, the contexts in the case(s) were quite sufficient.
3. How confident are you about the answers you gave for the problem solving tasks?
    a. I do not think I got the right answers
    b. I am not sure I got the right answers.
    c. I think my answers are right.
    d. I feel confident that I got the answers right.
    e. I feel very confident that I got the answers right.
4. After participating in this learning experiment, how do you evaluate your knowledge of Approval Voting?
    a. Very limited
    b. Limited
    c. Fair
    d. Good
    e. Very good

Is there anything confusing or not clear to you in the experiment? Please provide details below.

The description of AV:

Cases of AV:

The problem-solving tasks:

The questionnaire:

F. Demographics

1. At UGA, what year student are you?
    a. 1st year
    b. 2nd year
    c. 3rd year
    d. 4th year
    e. Higher than 4th year
2. Your number of years in college (UGA and elsewhere combined) is:
    a. One
    b. Two
    c. Three
    d. Four
    e. More than four
3. Your number of years of full time work experience is:
    a. One
    b. Two
    c. Three
    d. Four
    e. More than four
4. Your number of years of part time work experience is:
    a. One
    b. Two
    c. Three
    d. Four
    e. More than four

5. Your total years of work experience is:
    a. One
    b. Two
    c. Three
    d. Four
    e. More than four
6. Your gender is:
    a. Male
    b. Female
7. What is your GPA in UGA? _______________/4.0______
8. What is your SAT score used for the application to UGA? ___________