December 2006

Enhancing Knowledge Transfer Through Nurturing Cognitive Flexibility

Hui Wang
The University of Georgia

Jay Aronson
The University of Georgia

Enhancing Knowledge Transfer Through Nurturing Cognitive Flexibility

Hui Wang
Dept. of Management Information Systems
Terry College of Business
The University of Georgia
huiwang@terry.uga.edu

Jay E. Aronson
Dept. of Management Information Systems
Terry College of Business
The University of Georgia
jaronson@uga.edu

ABSTRACT

Knowledge transfer involves transferring knowledge from its native problem context to a different context, and adapting the knowledge according to the new conditions. It is an important source of organizational capability and a primary activity of knowledge management. The change of condition often creates major challenges to knowledge transfer. We explore this problem from the individual perspective. Drawing from the educational psychology and end-user training literatures, we posit that a knowledge worker's cognitive flexibility has a positive impact on knowledge transfer; and that a knowledge worker's cognitive flexibility with respect to a set of knowledge can be improved through learning that emphasizes cognitive flexibility. We argue that in a knowledge management system, knowledge should be represented to enhance a knowledge worker's cognitive flexibility, and consequently, improve knowledge transfer.

Keywords

Knowledge transfer, cognitive flexibility, knowledge representation, knowledge management

INTRODUCTION

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 a focus of Knowledge Management (KM) initiatives should be supporting and enhancing knowledge utilization (Alavi 2000). Knowledge transfer (KT), part of knowledge re-use and integration, has attracted growing research interest (Carlile and Rebentisch 2003). 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*. This definition is in line with the way the term is used by some KM researchers (Argote and Ingram 2000; Carlile and Rebentisch 2003; Szulanski 2000) and in the education literature. Contemporary studies report that, while the ability to re-apply knowledge in new situations is found to contribute to organizational performance (Argote and Ingram 2000), re-applying knowledge is nontrivial. For instance, maintaining and recreating a set of routines in a new setting is extremely challenging (Szulanski 2000). Our focus is on establishing a set of principles that promote effective knowledge transfer, thus ideally leading to the development of highly successful knowledge management systems.

Most existing KM research studies KT from an organizational perspective. While acknowledging the importance of the organizational approach, we call for better understanding of the phenomenon at the individual level, because it is ultimately knowledge workers' task to learn and apply knowledge. Alavi (2000) suggested borrowing from the psychology literature to investigate knowledge utilization through individuals' cognitive processes (problem solving and decision making). Following this call, we address the following questions here: What individual cognitive factors affect the effectiveness of KT? What characteristics of a knowledge management system (KMS) influence these factors? Drawing from the educational psychology and end-user training literatures, we argue that (1) a knowledge worker's cognitive flexibility (CF) improves his/her KT effectiveness; and (2) a knowledge worker's CF with respect to specific knowledge can be increased by emphasizing flexibility in the learning process.

The following sections introduce the theory basis, important existing research, the conceptual model and propositions, and a brief discussion of the importance of this study.

THEORY BASIS

Knowledge Transfer and Cognitive Flexibility

Reusing knowledge involves analyzing general principles (de-contextualized knowledge) against a specific situation – a process sometimes called the "re-contextualization" of knowledge (Markus 2001). KT happens when relevant prior knowledge is not already organized to fit a problem and therefore must be assembled from different knowledge sources in memory (Spiro and Jehng 1990; Spiro, Vispoel, Schmitz, Samarapungavan, and Boerger 1987). The KM literature suggests that KT is oftentimes challenging because transferring knowledge requires reconstruction and adaptation at the receiving end (Szulanski 2000); and when context changes lead to new requirements and novel conditions, they form a core challenge to KT (Carlile and Rebentisch 2003). 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 demands of a situation. In the educational psychology field, knowledge structures having this characteristic are labeled as cognitively flexible.

Educational psychology suggests that CF, "*the ability to spontaneously restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands* ..." (Spiro and Jehng 1990), is crucial to KT. CF has been discussed as an individual difference variable (Battig 1979), such as a component of general cognitive ability or intelligence (Carroll 1988). CF so defined is used as a control variable (a part of general intelligence) in this research. CF has also been considered a quality associated with specific knowledge. For instance, it was defined as 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), or the ability to relate the same concepts in different ways when the concepts are embedded in two different conceptual frameworks (Naveh-Benjamin, McKeachie, Lin, and Neely 1998). CF defined in this sense has been reported to be positively related to academic performance, and can be improved by using appropriate educational methods (Jacobson and Spiro 1995; Naveh-Benjamin et al. 1998; Spiro, Feltovich, Jacobson, and Coulson 1991; Spiro, Jacobsen, and Coulson 1991; Spiro and Jehng 1990).

Therefore, we purport that (1) knowledge workers' CF is positively related to their KT performances, and (2) an appropriately structured KMS should help to build CF with respect to its knowledge content. As to how to improve CF, we turn to the research on end-user training, education, and educational psychology.

A Framework of Learning

As suggested by educational psychology research, CF can be improved in learning. Bostrom, Olfman, and Sein (1990) provided a framework of learning which postulates that learners obtain knowledge of a learning target through forming and reforming mental models of the target; and that training methods, individual difference, and the learning target itself influence the formation of the mental model. A mental model is defined as *the learner's internal representation of the structure and function of the learning target* that provides explanatory and understanding power. 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 the target knowledge. Individual differences interact with training methods to affect learning outcomes. The framework is depicted in Figure 1.

Consistent with the definition of mental model, CF is an attribute of mental model. The internal representation of a knowledge system can be rigid or flexible. Per CF research, rigid representation, characterized by compartmentalized knowledge and little connection between concepts manifested in different situations, provides limited support to KT.

Per Bostrom et al.'s (1990) learning framework, training methods can be designed to enhance CF. The Cognitive Flexibility Theory (CFT) (Spiro et al. 1987) sheds lights on how knowledge should be acquired and organized to develop CF so as to facilitate a wide range of future applications. 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). CFT stresses the following principles: (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 be case-based and emphasize knowledge construction, not transmission of information; and (4) knowledge sources should be highly interconnected rather than compartmentalized. According to the experiential learning theory (Kolb and Fry 1975), individuals learn and solve problems by progressing through a four-stage cycle: concrete experience (CE) followed by reflective observation (RO), which leads to the formation of abstract concepts or abstract conceptualization (AC), which in turn leads to the testing of hypotheses through active experimentation (AE). Learners develop preferences for particular stages that are called learning modes. Integrating the four learning modes with CFT, we propose that training methods that emphasize CE and AE are more likely to improve CF than those emphasize RO and AC. CE can be used to implement the first two principles of CFT because multiple concrete

experiences can represent the same concept in different contexts. CE can also be used to execute the fourth principle and show the interconnection between the concepts in different situations. The third principle of CFT can be executed better with AE than with RO because compared with RO, AE requires doing rather than observing, which emphasizes knowledge construction and not transmission of information.

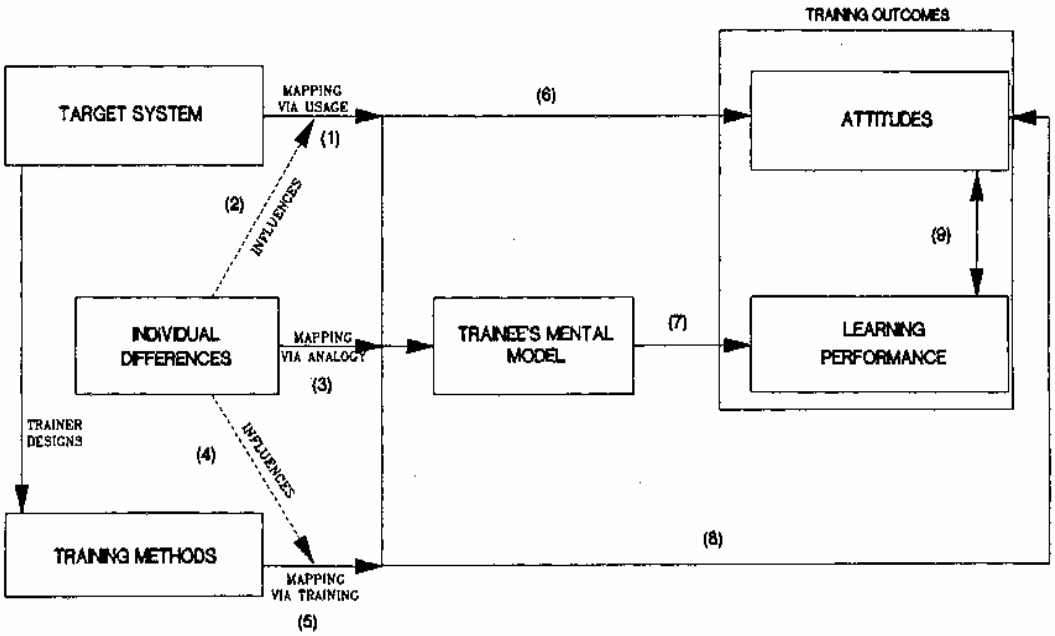

Figure 1. Bostrom et al.'s (1990) Framework for End-user Training

Individual difference variables that define the cognitive aspects of human activities are found to influence the learning outcome both directly through the formation of mental models, and indirectly through interactions with training methods (Bostrom et al. 1990; Olfman and Pitsatron 2000). Three individual difference variables, cognitive style, learning style, and general intelligence are recognized in previous research as closely related to learning outcomes and consequently considered here. Cognitive style is the individual preference of ways of organizing information. Unlike CF 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 (Kirton and Ciantis 1986). The adaption-innovation theory (Kirton 1976) identifies two extreme cognitive styles manifested in creativity, problem-solving, and decision-making – 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, while innovators will characteristically attempt to approach the problem from a new angle. The current study concerns a learner's ability to creatively re-assemble knowledge, therefore cognitive style is an important factor to measure.

Learning style theories suggest that an individual's learning style affects learning. Using Kolb's learning style theory (Kolb and Fry 1975), Bostrom et al. (1990) investigated the impact of two learning styles, *abstract learners* versus *concrete learners*, on learning outcomes and their interaction with training methods. The learning style theory postulates that a learner prefers to gather information either through abstract conceptualization or concrete experience, then process that information through either reflective observation or active experience. For instance, abstract conceptualizers and concrete experiences favor opposite learning modes. An individual's learning style is relevant to the current study in that it may interact with training methods which vary on the level of abstraction and experimentation.

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 the knowledge specific CF as defined in this study 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. We argue that, people with high general cognitive flexibility tend to develop higher CF with respect to the learning target than people with low general cognitive flexibility who go through the same learning process. This study will test this hypothesized interacting effect.

CONCEPTUAL MODEL AND PROPOSITIONS

Based on the previous discussion, we present a conceptual model which links training methods to KT, as mediated by a knowledge worker's CF. The model postulates that with training methods designed according to the principles of CFT, a learner's CF can be improved, which in turn, will enhance KT. Individual difference variables affect KT through the mediation of CF. The model is depicted in Figure 2. Five propositions are developed. Proposition 1 is the main effect of training methods on CF. Proposition 2 is the main effect of CF on KT. Proposition 3 is the moderating effect of learning style on CF. Proposition 4 is the moderating effect of training methods on cognitive style. Proposition 5 is the moderating effect of training methods on general intelligence.

Proposition 1. Ceteris paribus, training methods that emphasize CE and AE leads to higher level of CF than those emphasizing AC and RO.

Proposition 2. Ceteris paribus, higher CF leads to better KT performance.

Proposition 3. When the training method emphasizes CE and AE, individuals with a learning style that favors CE and AE are likely to develop higher CF than others.

Proposition 4. Individuals with a cognitive style that is characterized as habitual innovator in general develops higher CF than those with a cognitive style characterized as habitual adaptor; when training methods that emphasize CE and AE are used, the differences in CF between habitual innovators and habitual adaptors are smaller than when training methods that emphasize AC and RO are used.

Proposition 5. Individuals with a high level general intelligence normally develops higher CF than those with a lower level general intelligence; when training methods that emphasize CE and AE are used, the differences in CF between those with high general intelligence and those with lower general intelligence are smaller than when training methods that emphasize AC and RO are used.

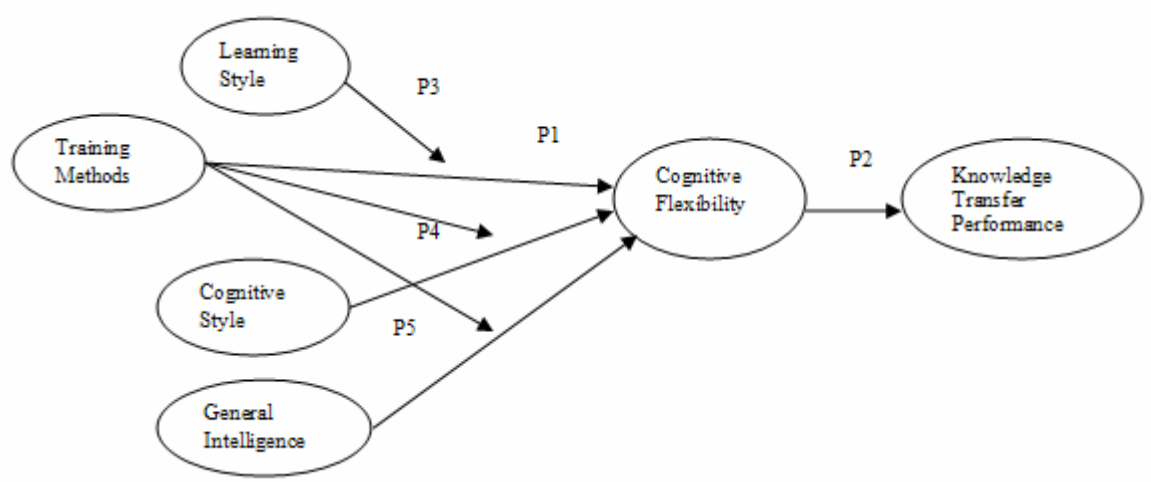

Figure 2. Conceptual Model of CF and Knowledge Transfer

IMPORTANCE OF RESEARCH

Organizations are competing on the basis of knowledge to an ever increasing level. It has become critical for organizations to effectively apply their knowledge to create solutions. As an organizational mechanism to facilitate this process, a KMS must provide a rich and flexible view of the complex conceptual landscape of existing knowledge. Yet, it is challenging to document knowledge because it is rooted in context. How to handle context in knowledge documentation forms a major challenge of KM (Alavi and Leidner 2001). In addition, the organizational contingencies are complex and therefore it is

difficult to provide a single complete knowledge framework. Thus far, we have found no well-developed research and application guidelines of how to document complex knowledge in a KMS to support effective knowledge transfer. Hence we shall attempt to investigate this problem from an individual's cognitive perspective. To the extent that important individual differences such as cognitive style and learning style can be assessed, the organization can identify people who might be well-suited for KT work.

REFERENCES

1. Alavi, M. (2000) Managing Organizational Knowledge, in R.W. Zmud (Ed.) *Framing the Domains of IT Management: Projecting the Future from the Past,* Pinnaflex Educational Resources, Cincinnati, OH, 15-28.
2. Alavi, M. and Leidner, D.E. (2001) Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues, *MIS Quarterly,* 25, 1, 107-136.
3. Argote, L. and Ingram, P. (2000) Knowledge Transfer: A Basis for Competitive Advantage in Firms, *Organizational Behavior and Human Decision Processes,* 82, 1, 150-169.
4. Battig, W.F. (1979) Are The Important "Individual-Differences" Between or Within Individuals?, *Journal of Research in Personality,* 13, 4, 546-558.
5. Bostrom, R.P., Olfman, L. and Sein, M.K. (1990) The Importance of Learning Style in End-User Training, *MIS Quarterly,* 14, 1, 101-119.
6. Carlile, P.R. and Rebentisch, E.S. (2003) Into the Black Box: The Knowledge Transformation Cycle, *Management Science,* 49, 9, 1180-1195.
7. Carroll, J.B. (1988) Individual Differences in Cognitive Functioning, in R.C. Atkinson, R.J. Hernstein, D. Lindzey and R.D. Luce (Eds.) *Stevens' Handbook of Experimental Psychology,* Wiley, New York, 813-962.
8. Jacobson, M.J. and Spiro, R.J. (1995) Hypertext Learning Environments, Cognitive Flexibility, and the Transfer of Complex Knowledge: an Empirical Investigation, *Journal of Educational Computing Research,* 12, 4, 301-333.
9. Kirton, M. (1976) Adaptors and Innovators - Description and Measure, *Journal of Applied Psychology,* 61, 5, 622-629.
10. Kirton, M.J. and Ciantis, S.M.D. (1986) Cognitive Style and Personality: The Kirton Adaption-Innovation and Cattell's Sixteen Personality Factor Inventories, *Personality and Individual Differences,* 7, 2, 141-146
11. Kolb, D.A. and Fry, R. (1975) Towards an Applied Theory of Experiential Learning, in C.L. Cooper (Ed.) *Theories of Group Processes,* Wiley, New York, NY, 33-57.
12. Kolodner, J.L. (1997) Educational Implications of Analogy - A View from Case-based Reasoning, *American Psychologist,* 52, 1, 57-66.
13. Markus, M.L. (2001) Towards a Theory of Knowledge Reuse: Types of Knowledge Reuse Situations and Factors in Reuse Success, *Journal of Management Information Systems,* 18, 1, 57-94.
14. Naveh-Benjamin, M., McKeachie, W.J., Lin, Y.-G. and Neely, R.K. (1998) Assessment and Modification of Flexibility of Cognitive Structures Created in University Courses, *Contemporary Educational Psychology,* 23, 3, 209-344.
15. Nonaka, I., Toyama, R. and Nagata, A. (2000) A Firm as a Knowledge-creating Entity: A New Perspective on the Theory of the Firm, *Industrial and Corporate Change,* 9, 1, 1-20.
16. Olfman, L. and Pitsatron, P. (2000) End-user Training Research: Status and Models for the Future, in R.W. Zmud. (Ed.) *Framing the Domains of IT Management: Projecting the Future through the Past,* Pinnaflex Education Resources, Inc., Cincinnati, OH.
17. Spiro, R.J., Feltovich, P.J., Jacobson, M.J. and Coulson, R.L. (1991) Knowledge Representation, Content Specification, and the Development of Skill in Situation-specific Knowledge Assembly: Some Constructivist Issues as They Relate to Cognitive Flexibility Theory and Hypertext, *Educational Technology,* 31, 9, 22 - 25.
18. Spiro, R.J., Jacobsen, M.J. and Coulson, R.L. (1991) Cognitive Flexibility, Constructivism, and Hypertext: Random Access Instruction for Advanced Knowledge Acquisition in Ill-Structured Domains, *Educause Review,* 26, 5, 24–33.
19. Spiro, R.J. and Jehng, J.-C. (1990) Cognitive Flexibility and Hypertext: Theory and Technology for the Nonlinear and Multidimensional Traversal of Complex Subject Matter, in D. Nix and R. Spiro (Eds.) *Cognition, Education, and Multimedia: Exploring Ideas in High Technology,* Lawrence Erlbaum Associates, Hillsdale, NJ, 163-205.
20. Spiro, R.J., Vispoel, W.P., Schmitz, J.G., Samarapungavan, A. and Boerger, A.E. (1987) Knowledge Acquisition for Application: Cognitive Flexibility and Transfer in Complex Content Domains, in B.K. Britton and S.M. Glynn (Eds.) *Executive Control Processes in Reading,* L. Erlbaum Association, Hillsdale, NJ, 177-199.
21. Szulanski, G. (2000) The Process of Knowledge Transfer: A Diachronic Analysis of Stickiness, *Organizational Behavior and Human Decision Processes,* 82, 1, 9-27.