Enhancing Knowledge Management Process in Academic Tutoring: The use of Domain Memory and Scenarios

Babajide Osatuyi
New Jersey Institute of Technology
Department of Information Systems
University Heights, Newark, NJ 07102
Tel: 585-208-8348
Email: bj04@njit.edu

Francis Kofi Andoh-Baidoo
The University of Texas-Pan American
College of Business Administration
Department of Computer Information Systems and Quantitative Methods
1201 W. University Drive, Edinburg, Texas 78539-2999
Tel: 956-381-3397
Email: andohbaidoof@utpa.edu

Jon Blue
University of Delaware
College of Business and Economics
Department of Accounting and Management Information Systems
42 Amstel Avenue, 222 Purnell Hall, Newark, DE 19716-2715
Tel: 302-831-6002
Email: jonblue@udel.edu

Abstract

Institutions of higher learning appropriately use tutoring services to enhance students' learning. Typically, professors recommend students who exhibit excellent academic skills in a particular course or program to student learning centers to work as tutors. Tutors gain problem solving knowledge in their specific domain. This knowledge which is ingrained in the minds of individual tutors but difficult to explicate to tutees or other tutors is referred to as tacit. Institutions of higher learning can leverage the expertise of their tutors by capturing such tacit knowledge into a repository for knowledge sharing. Although several tutoring systems have been proposed to enhance the tutoring process, existing systems do not capture tacit knowledge that can be used by others. In this paper, we present an approach for sharing knowledge that utilizes features of domain memory information systems with Scenario Accumulator to support academic tutoring. This approach uses Scenarios for capturing tacit knowledge and ontology for standardizing data from diverse knowledge sources, as well as presenting common understanding of concepts among the tutors and tutees. Using the Nonaka and Takeuchi's knowledge spiral model, we demonstrate how the architecture supports the knowledge management process from the acquisition of tacit knowledge through the sharing of explicit knowledge among tutors and tutees.

Keywords: Ontology, Tacit knowledge, Scenarios, Tutor, Domain Memory Information System

1. INTRODUCTION

Institutions of higher learning appropriately use tutoring services to enhance students' learning. Studies show that one-on-one tutoring is more effective in learning process than the traditional classroom setting (Cohen et al, 1984). However, students who are recommended to become tutors are not selected until their second or third year of school. This leaves them with a short period to share the knowledge that is ingrained in their minds (known as tacit knowledge). Computer based learning environments have been developed to simulate one-on-one tutoring on the web or on standalone systems in order to retain tutors' tacit knowledge (Osatuyi, 2007; Busch, Richards, & Dampney, 2000; Grant & Gregory, 1997).

The "first generation" computer based learning environments introduced only one advantage as compared to the human tutors —individualized interactive learning support (Corbett Albert & Trask Holly, 2000). Second generation tutor systems emerged in the 1980s and incorporated artificial intelligence technology into computer tutors.

Repeated studies have documented that tacit knowledge can be articulated, captured, and represented (Busch, Richards, & Dampney, 2000; Grant & Gregory, 1997; Nonaka, Takeuchi, & Umemoto, 1996; Raghuram, 1996; Howells, 1995; Goldman, 1990; Pylyshyn, 1981). Cheah & Abidi (2000b) presented a healthcare Tacit Knowledge Acquisition Info-structure (TKAI) tool that allows remote healthcare practitioners to record their tacit knowledge. However, the traditional computer based learning environment does not possess capabilities to acquire, store, and use tacit knowledge (Cheah & Abidi, 1999). Researchers have indicated that integrating knowledge processes and learning processes would enhance the creation of new knowledge (Bolloju, Khalifa, & Turban, 2002; Nemati et al., 2002).

In this paper, we present an approach for sharing knowledge that integrates features of domain memory information systems, with Scenario Accumulator to support academic tutoring. This approach includes capturing tacit knowledge and uses ontology for standardizing and organizing the diverse data and knowledge sources as well as presenting common understanding of concepts among the tutors and tutees. We use Nonaka and Takeuchi's knowledge spiral model to demonstrate how the architecture supports the knowledge management process from the acquisition of tacit knowledge through the sharing of knowledge among tutors and tutees.

The organization of the paper is as follows. In section 2 we review tutoring, and tutoring applications. Following this discussion, we describe our conceptual framework and how that integrates functional features of Domain Memory Information Systems (DMIS). DMIS will be used interchangeably with Organizational Memory Information Systems in this paper. In Section 4 we introduce the architecture, Scenario Accumulator, and a description of its components. This is done using Scenarios to facilitate the acquisition, storage, use and sharing of tacit knowledge and ontologies for standardizing raw knowledge input from tutors. In Section 5 we discuss how the proposed architecture supports Nonaka and Takeuchi's knowledge spiral model. Finally, we conclude the paper with possible future research directions.

2. LITERATURE REVIEW

2.1 TUTORING

Tutoring is an important means that higher institutions of learning use to enhance students' learning. Professors and advisors recommend students who exhibit excellent academic skills in a particular course or program to become tutors. Tutors gain problem solving knowledge in their specific domain, which is what they explicate when assisting tutees in solving problems and getting answers. Research shows that both the tutors and the tutees benefit from the tutoring process (Beasley, 1997). The tutors' benefits include: heightened sense of competency or adequacy in conforming to the new role, encouragement in higher levels of thinking, increased subject specific and related general knowledge (Dineen et al., 1977). The tutees also enjoy such benefits as individualized, systematic, structured learning experience; greater congruence between tutor and tutee — closer role model; and most importantly, improved academic performance and personal growth and hence, better attitude towards the subject area.

Although tutoring has proven to be highly effective as a result of noticed improvement in the academic performance of the tutees compared to other students in their classes, the whole process of knowledge transfer from tutors to tutees is very difficult (O'Riain, Zhou et al. 2004).

Hattie (1992) stated that peer tutoring does not satisfy several individualized programs even though peer tutoring claims to be successful as a result of its one-on-one mode of interaction. Hattie's argument was buttressed by arguments that one-on-one tutoring does not guarantee effective teaching but that it rather enhances feedback, and directs tutor attention on matching curricular demands with the tutee's prior knowledge (Hattie, 2006).

2.2 TUTORING APPLICATIONS

Kim et al. (2005) proposed architecture to provide the intelligent student support system, which uses ontology and semantic web to enhance communication between different agents. Similarly, Lu et al. (2004) proposed a design of an ontological representation scheme called process map (PM) to represent procedural knowledge, which seeks to identify the activity structure from given behavioral models of components and their connective relations to the components. This concept of procedural knowledge is intended to be used in intelligent tutoring systems to accumulate the knowledge of a teacher/curriculum manager and student model.

The student model measured student's knowledge in a particular domain. Tsu, Hsu, and Wu (2002) propose a process called Identification, Simulation, Interaction and Mapping Schema, which detects underlying cognitive reasons for errors as a result of incorrect answers provided by students.
Pasier and Jeuring (2004) stress the importance of feedback in the educational system. They present a plan to create a rich supply of feedback, which will augment the question-answer–situation with a mechanism based on ontologies in the context of design oriented education. We add to the literature on knowledge management and tutoring. The proposed architecture facilitates the knowledge management process from the acquisition of tacit knowledge through the sharing of explicit knowledge among tutors and tutees.

3. CONCEPTUAL FRAMEWORK

3.1 KNOWLEDGE MANAGEMENT

O'Leary (1998) defines knowledge management as the formal management for facilitating the creation, access, and reuse of knowledge, typically using advanced technology. The management and processing of organizational knowledge are increasingly being viewed as critical to organizational success (Inkpen et al, 1998). The field of Knowledge Management curtails from the realization that an organization cannot afford to lose knowledge as individuals leave. Knowledge management is a process implemented over time (Benjamins, Fensel, & Perez, 1998). Knowledge comes in two forms: explicit and tacit (Polanyi, 1966). Explicit knowledge is systematic and can be expressed formally as language, rules, objects, symbols, or equations. Thus, explicit knowledge is communicable as mathematical models, universal principles, or written procedures (Nemati et al., 2002).

Tacit knowledge includes the beliefs, perspectives, and mental models ingrained in a person's mind. This type of knowledge is hard to transfer or verbalize because it cannot be broken down into specific rules. However, many authors have purported that this type of knowledge can be articulated, captured, and represented (Busch, Richards, & Dampney, 2000; Grant & Gregory, 1997; Takeuchi, Nonaka & Umemoto, 1996; Raghuram, 1996; Howells, 1995; Goldman, 1990; Pylyshyn, 1981).

Nonaka and Takeuchi (1995) assert that new knowledge is created through the synergistic relationship and interplay between tacit and explicit knowledge. This concept, depicted with the Knowledge Spiral (Figure 1), has four spokes: (1) Externalization (conversion of Tacit knowledge to new knowledge (explicit)), (2) Combination (conversation of explicit knowledge to new knowledge (explicit)); (3) Internalization (learning new knowledge (explicit – by doing) and conversion of explicit knowledge to tacit knowledge); and (4) Socialization (sharing tacit knowledge). These four knowledge conversion processes are interdependent; mutually complementary; based on the context and sequence, changeable, and continuously cycle.

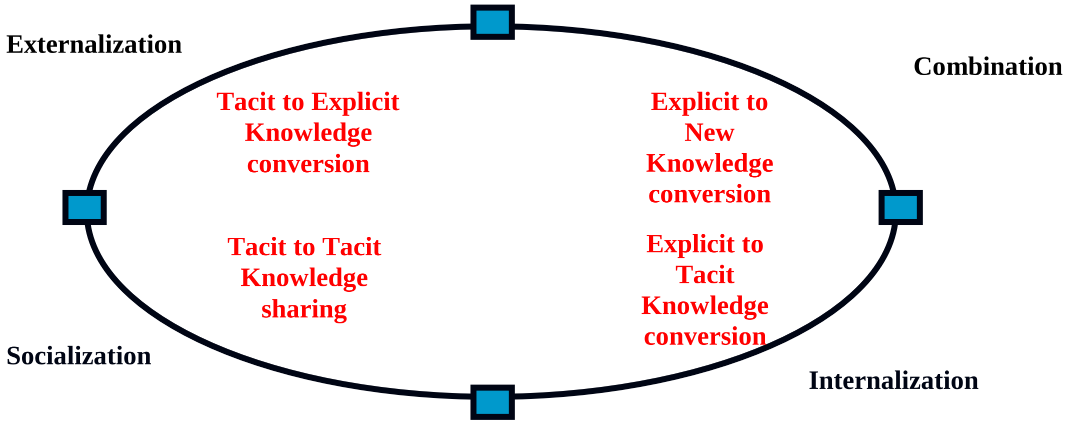

Figure 1: The Knowledge Spiral (Adapted from Nonaka and Takeuchi (1995)).

Externalization involves the conversion of tacit knowledge to explicit knowledge. It allows the explicit specification of tacit knowledge. Combination is the knowledge conversion step where explicit knowledge is converted to new explicit knowledge. New explicit knowledge is learnt during the Internalization process. In this process, explicit knowledge is converted to implicit (tacit) knowledge. Socialization is sharing tacit knowledge, i.e. tutors share their tacit knowledge with other tutors during social settings.

3.2 DOMAIN MEMORY INFORMATION SYSTEMS

Studies have shown that DMIS architecture can be effective since it allows for the reuse of previous domain knowledge which thereby supports domain learning (Vasconcelos, Gouveia, and Kimble, 2002; Liao, 2003). A DMIS is an integrated knowledge based information system with culture, history, business processes, and human memory attributes (Hackbarth, 1998). Hackbarth proposes that direct activities related to experiences and observations must be stored by a DMIS in a suitable format to match individual cognitive orientations and value systems. Atwood (2002) presents applications of DMIS in various domains including corporate environments and governmental settings.

A DMIS is expected to bring knowledge from the past to bear on future activities that would enhance organizational responsiveness. For instance, Heijst et al. (1997) suggest that DMIS facilitates organizational learning in three ways: individual learning, learning through direct communication, and learning using a knowledge repository.

4. PROPOSED ARCHITECTURE

The Scenario-based architecture comprises four main components: Meta-Scenario, Scenario-Construct, Episode and Event. The four components are described below.

4.1 META-SCENARIO COMPONENT

The Meta-Scenario component can be categorized into class and sub-class scenarios. Each category is referred to as a class of scenarios, which has series of sub-class elements (Cheah & Abidi 2000a). The sub-class contains a "Scenario List" element, which holds records (Scenario IDs), by date and time, of captured hypothetical sub-class scenario. A typical representation of the meta-scenario component is shown in Figure 2.

	Example
Class ID	LA001
Class Name	LINEAR_ALGEBRA
Scenario Sub-Class	Linear equations
Scenario List	2006620.1040, 2006621.1415
..	
Scenario Sub-Class	Matrices
Scenario List	2006820.1500, 2007210.0900

Figure 2: Representation of a sample Class in a Meta-Scenario (shaded rows indicate the Sub-Class List element)

4.2 SCENARIO-CONSTRUCT COMPONENT

The Scenario-Construct is a repository of individual scenarios that contains a unique Scenario ID – encoded as the date and time of capture of the scenario. It contains a description of the scenario and a chronological sequence of episodes to mimic the temporal characteristics of the scenario. This feature of the Scenario construct allows for easy traceability with regard to the chain structure of the episodes within a scenario (Cheah & Abidi, 2000a). The Scenario-Construct has a contextual link field, which stores keywords to help locate information that pertains to the episodes and events of a particular scenario. A representation of the Scenario-Construct is shown in Figure 3a.

	Example
Scenario ID	2006620.1040
Scenario Description	Solve homogeneous system of linear equation problem. Value(s): integers. Solution Type: Gauss-Jordan elimination.
Contextual Link	Homogeneous, Linear equation, Gauss-Jordan.
Start Timestamp	1040
End Timestamp	1112
Trigger Event	EV0001
Episode List	EP0001, EP0002, EP0003, EP004
Concluding Event	EV0020

Figure 3a: Representation of a scenario-construct component

	Example
Episode ID	EP0001
Episode Description	Assessments
Event List	EV0002, EV0003, EV0005

Figure 3b: Representation of an episode component

	Example
Event ID	EV0006
Event Type	Action
(Actor)	Tutor
(Object)	Tutee
Parameter-Value-List	PV0004

Figure 3c: Representation of an event component

4.3 EPISODE COMPONENT

The Episode component contains details of each episode of a scenario. It also comprises an event list that stores a sequence of events. This sequence of events makes up an episode in a scenario. A representation of the episode component is shown in Figure 3b.

4.4 EVENT COMPONENT

The event component contains details of each event. It comprises an Event Type, which is expressed by an actor on an object. The Event Types can be Normative— events expected to occur on a normal basis, Obstacle—events that hinder the progress of a task, and Action—events that define the course of action undertaken by an actor [13]. A representation of the event component is shown in Figure 3c.

5. THE KNOWLEDGE SPIRAL APPLIED TO SCENARIO ACCUMULATOR

Given the main components of the Scenario Accumulator, we now show how it is used to support Nonaka and Takeuchi's knowledge spiral model: externalization, combination, internalization, and socialization.

5.1 EXTERNALIZATION – (TACIT KNOWLEDGE ACQUISITION)

In order to improve the capture of domain knowledge, Protégé 2000 has been used to develop a tool called the Scenario Accumulator. This tool uses a series of electronic forms whose attributes correspond to a specific component of a scenario: Meta-Scenarios, Scenario-Constructs, Episodes and Events. The tool allows domain experts to respond to a series of hypothetical events that ultimately results in a scenario. Domain experts are prompted to provide or suggest informational values to the attributes of a scenario in the electronic form. A sample screenshot of the Scenario Accumulator is depicted in Figure 4.

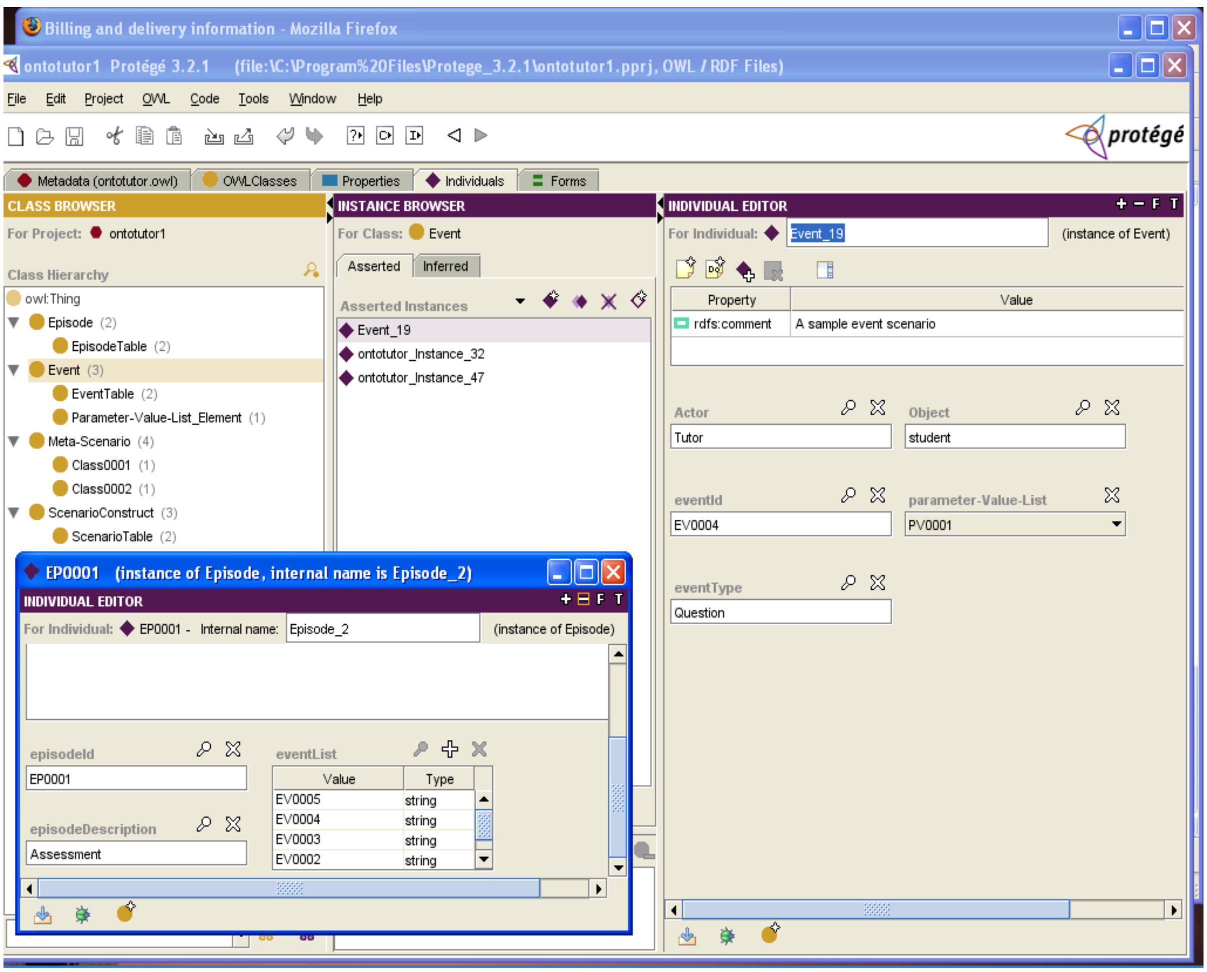

Figure 4: Screenshot of Episode and Event.

In order to facilitate an assortment of scenario acquisition activities, scenarios are distinguished as:

1. *Solved Scenarios*: These are scenarios of actual circumstances and problems encountered and solved by domain experts. Scenario bases typically start out as having only solved scenarios. Solved scenarios may be modified to form challenge scenarios.
2. *Challenge Scenarios*: These are scenarios that represent hypothetical situations and are presented to domain experts to challenge their expertise. Domain experts respond to such challenges and explicate their tacit knowledge to address or solve the posed problem. Challenge scenarios are often achieved from scenario bases by selecting a *Point of Interrogation (POI)* — a specific point in the scenario between two events of type *Obstacle* or *Normative* and an event of type *Action*.

Since there is no set limit to the extent to which tutors explicate their knowledge, contents of the Scenario Accumulator will be integrated into ontology. Ontology can be integrated before or after the scenario capture. However, because a tutor can express him or herself in many ways given the same event, a "pre-input" form of ontology integration is considered. The pre-input ontology are terms used by the tutors that are standardized by the system before added to the scenario base. Tutors, as earlier stated, are often selected in their junior or senior year, which leaves them with a limited time to be physically present at the learning centers to help students. The advantage of the standardization is to prevent ambiguity in the inevitable event of the tutor's absence for clarification of terms used in the scenario.

5.2 COMBINATION

Ontology reconfigures the explicit knowledge in the Scenario Accumulator. Through the daily interaction with the Scenario Accumulator, tutors explicate knowledge using the explicit knowledge that has been captured from diverse knowledge and data sources (e.g., textbooks, tapes, videos, CDs, other tutors). Tutees can also use the explicit knowledge in the Scenario Accumulator in the process of settling a cognitive conflict. A cognitive conflict is regarded as one's awareness of contradiction between the cognitive structure (prior knowledge) and the external information (Amichai-Hamburger & Furnham, 2007).

5.3 INTERNALIZATION

New knowledge is learnt during the Internalization stage. Explicit knowledge is converted to implicit knowledge. Explicit to implicit knowledge conversion occurs with a modification of a knowledge worker's internal mental model and can occur after discovering new relationships. As tutors gain a better understanding of how they can improve their activities through the shared knowledge from the Scenario Accumulator, they gain new tacit knowledge about their work by performing as the Scenario Accumulator instructs. The Scenario Accumulator becomes a support system as the knowledge workers validate the new knowledge that has been created.

5.4 SOCIALIZATION

Ontology facilitates the creation of common vocabulary for communication among the tutors and tutees. The shared understanding then serves as the basis for expressing knowledge contents and for sharing and managing knowledge in academic tutoring. The knowledge management literature suggests that sharing of tacit knowledge through socialization is effective in small groups (Von et al., 2000).

6.CONCLUSION

In this paper, we have presented an approach for sharing knowledge that utilizes features of DMIS with Scenario Accumulator to support academic tutoring. We have discussed how Scenarios can be employed to facilitate the acquisition and representation of tacit knowledge into the Scenario Accumulator and use ontologies for standardizing input data from diverse tutors. Future research is planned to determine the exact level of effectiveness and where improvements can be made in the Scenario Accumulator tool and to the process.

There has been an extensive amount of research on ontology and its application to knowledge management. The use of ontologies has been proven to be effective and efficient in this task. The inclusion of *Scenarios* in the solution is justified by appealing to the research and studies that have been presented to show the effectiveness of *Scenarios* in acquiring tacit knowledge.

While in this paper we specifically applied Nonaka and Takeuchi's (1995) Knowledge Spiral to demonstrate how the architecture facilitates the knowledge management process, there are similar philosophies that can be used in future research. For instance, Frappaolo (1998) says that knowledge management technologies are expected to create innovation by supporting the following activities: externalization, internalization, intermediation and cognition. Externalization is the process of capturing knowledge repositories and matching them to other knowledge repositories. Internalization seeks to match bodies of knowledge to a particular user's need to know (transfer of explicit knowledge). Intermediation matches the knowledge seeker with knowledge by focusing on tacit knowledge or experience level in the organization. Cognition is the process by which tutees learn a concept based on available knowledge by matching knowledge with prior understanding. Clearly three of these activities are directly related to the knowledge spiral that the Scenario Accumulator supports.

Additionally, future research steps could integrate ontologies in a pre- and post-input manner. It can be viewed as either practical or immediate. This means standardization before and after a scenario is accepted into the scenario base. Ideally, this should be done before a scenario is accepted to avoid ambiguity due to the short period of time tutors are available to provide clarification.

References

Alavi, M., & Leidner, D. (2001), "Knowledge Management and Knowledge Management Systems: Conceptual Foundation and An Agenda for Research," *MIS Quarterly*, March, 107-136.

Amichai-Hamburger, Y. & Furnham, A. (2007). The positive net.*Computers in Human Behavior*, 23, 1033-1045

Atwood, M.E. (2002). Organizational Memory Systems: Challenges for InformationTechnology. In *Proceedings of 35th HICSS.* pp. 1-9.

Benjamins, V.R., Fensel, D., & Perez, A.G. (1998). Knowledge Management through Ontologies. *In Proceedings of the Second International Conference of Practical Aspects of Knowledge Management (PAKM 98), October 29-30.*

Bolloju, N. Khalifa, M, & Turban, E. (2002). Integrating Knowledge Management into enterprise environments for the Next Generation Decision Support. *Decision Support Systems.* Vol. 33. pp. 163-176.

Busch, P., Richards D., & Dampney, C.N.G. (2000). Mapping Tacit Knowledge Flows in Organisation X. *In Proceeding of the 11th Australasian Conference on Information Systems, Brisbane, Australia, December 5-7,,*pp.85 – 94.

Cheah, Y., & Abidi, S. S. R. (1999). Tacit Knowledge Creation in a Knowledge Management Context, *14th International Symposium on Computer and Information Sciences*.

Cheah, Y, & Abidi, S.S.R., (2000a) "A Scenarios Mediated Approach for Tacit Knowledge Acquisition and Crystallization: Towards Higher Return-On-Knowledge and Experience", The Third International Conference on Practical Aspects of Knowledge Management (PAKM 2000), Basel, Switzerland, 2000.

Cheah, Y., & Abidi, S.S.R. (2000b). Healthcare Knowledge Acquisition: An Ontology-Based Approach Using the Extensible Markup Language (XML). *Medical Infobahn for Europe (MIE 2000), Hannover, Germany* , pp. 827-831

Corbett Albert & Trask Holly, "Instructional Interventions in Computer-Based Tutoring: Differential Impact on Learning Time and Accuracy", *Proceedings of ACM CHI'2000 Conference on Human Factors in Computing Systems, 97-104. New York: ACM Press.*

Dineen J. P., Clark H. B., and Risely T. R., "Peer Tutoring among Elementary Students: Educational benefits to the tutor", Journal of Applied Behavior Analysis, 1977,10 ,231-238.

Frappaolo, C. (1998). What's in a name? *KMWorld.* March 16, pp. 18-19.

Genesereth, M.R., Nilsson, N.J. (1987). *Logical Foundations of Artificial Intelligence*, San Mateo, CA: Morgan Kaufmann Publishers.

Goldman, G. (1990). The tacit dimension of clinical judgment, *The Yale Journal of Biology and Medicine*, *63(1)*, 47-61.

Grant, E., Gregory, M. (1997). Tacit knowledge, the life cycle and international manufacturing transfer, *Technology Analysis & Strategic Management 9(2)*, 149–161.

Hackbarth, G. (1998). The Impact of Organizational Memory on IT Systems, In *Proceedings of the Fourth Americase Conference on Information Systems,* E. Hoadley and I. Benbasat (eds)., pp. 588-590.

Hattie, J.,"Cross-Age Tutoring and the Reading Together Program", Studies in Educational Evaluation 32 (2006) 100-124.

Heijst, G., Spek, R., & Kruizinga, E. (1997). Corporate memories as a tool for knowledge management. Expert Systems With Applications, 13(1), 41–54.

Howells, J. (1995). Tacit Knowledge and Technology Transfer, *Working paper No. 16 ESRC Centre for Business Research and Judge Institute of Management studies*, University of Cambridge U.K. September.

Inkpen Andrew C., Dinur Adva, "Knowledge Management Processes and International Joint Ventures", Organization Science, Vol. 9, No. 4 (Jul. – Aug., 1998), pp. 454-468.

Inmon, W. (1995). *What is a Data Warehouse?* Prism Tech Topic, Vol.1, No. 1.

Jang, D.-H., & Myaeng, S.H. (1997). Development of a document summarization system for effective information services, RIAO 97 Conference Proceedings: Computer-Assisted Information Searching on Internet, Montreal, Canada, pp. 101– 111.

Kavalki, E., P. Loucopoulos, & D. Filippidou (1996). Using Scenarios to Systematically Support Goal-Directed Elaboration for Information System Requirements, *Information Systems Engineering Group*. Department of Computation, UMIST, Manchester, Technical Report ISE-96-1.

Keen, P.G.W., & Scott Morton, M.S. (1978). DSS: An Organizational Perspective, Addision-Wesley, Reading, MA.

Kim T., Kim M. and Park G., "On employing Ontology to e-learning", Proceedings of the Fourth Annual ACIS International Conference on Computer and Information Science (ICIS '05).

Kupiec, J., Pedersen, J., & Chen, F. (1995) A trainable document summarizer, in: E.A. Fox, P. Ingwersen, R. Fidel (Eds.), SIGIR-95: Proceedings of the 8th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval, ACM press, New York, NY, pp. 68– 73.

Liao, S-H. (2003). Knowledge Management technologies and Applications – literature Review from 1995 to 2002. *Expert Systems with Applications*, Vol. 25, No. 2, pp. 155-164.

Lu C., Wu S., Tu L., Hsu W., "The Design of An Intelligent Tutoring System Based on the Ontology of Procedural Knowledge", Proceedings of the IEEE International Conference on Advanced Learning Technologies (ICAL '04).

Mohan, Madan, "Peer Tutoring as a Technique for Teaching the Unmotivated", 1972-01-00, ED061154 www.eric.ed.gov

Nemati, H.R., Steiger, D.M., Iyer, L.S., & Hershel, R.T. (2002). Knowledge warehouse: an architectural integration of knowledge management, decision support, artificial intelligence and data warehousing, *Decision Support Systems*, Volume 33, Issue 2, June, 143-161.

Neumann, G., & Strembeck M. (2002). A scenario-driven role engineering process for functional RBAC roles, *7th ACM Symposium on Access Control Models and Technologies, June 3-4, 2002, Naval Postgraduate School, Monterey, California, USA*, pp. 33-42.

Nonaka, I., & Takeuchi, H. (1995). The Knowledge-Creating Company, How Japanese companies manage the dynamics of innovation, Oxford University Press, New York.

Nonaka, I., Takeuchi, H., & Umemoto K. (1996). A theory of organizational knowledge creation, *International Journal of Technology Management*, 11(7/8), 833 – 845.

O'Leary, D.: Using AI in knowledge management: Knowledge bases and ontologies. *IEEE Intelligent Systems* 13 (1998) 34–39.

O'Riain, S., Zhou, X., Li, J., O'Sullivan, D., Croke, P., & Precup, L. 2004. D8.1 Knowledge Management (Tools & Technologies), National University of Ireland Galway Hewlett Packard Galway Ltd., Galway, Ireland.

Passier H and Jeuring J, "Ontology Based Feedback Generation in Design-Oriented E-Learning Systems", IADS e-Society 2004 Conference.

Peter A. Cohen, James A. Kulik, Chen-Lin C. Kulik ,"Educational Outcomes of Tutoring: A Meta-Analysis of Findings", *American Educational Research Journal*, Vol. 19, No. 2 (Summer, 1982), pp. 237-248**.**

Polanyi, M. (1966). *The Tacit Dimension*. Routledge and Kegan Paul, London, UK, 1966.

Potts, C., Takahashi, K., & Anton, A. (1994). *Inquiry-based scenario analysis of systems requirements* Technical Report GIT-CC-94/14, Georgia Tech.

Pylyshyn, Z. (1981). The imagery debate: Analogue media versus tacit knowledge, *In Readings in Cognitive Science: A perspective from Psychology and Artificial Intelligence* (eds. Collins, A., Smith, E.), Chapter 6.5 Morgan Kaufman San Mateo California U.S.A., pp. 600 – 614.

Raghuram, S. (1996). Knowledge creation in the telework context, *International Journal of Technology Management*, (11)7–8, 859 – 870.

Richards, D. & Busch, P. (2001). Acquiring and Applying Contextualised Tacit Knowledge. *Australian Conference for Knowledge Management & Intelligent Decision Support (ACKMIDS' 2001)*, Melbourne, Australia, 10-11 December.

Sheth, A. (2003). Semantic Meta Data for Enterprise Information Integration, *DM Review*, July.

Simon, H.A. (1955). A Behavioral Model of Rational choice. *Quarterly Journal of Economics*, Vol. 69, pp. 99-118.

Sprague, R.H., Jr., & Carlson, E.D. (1982). *Building Effective Decision Support Systems.* Prentice-Hall, Englewood Cliffs, N.J.

Staudt, M., Vaduva, A, & Vetterli, T. (1999). The Role of Metadata for Data Warehousing, Technical Paper, Universit of Zurich.

Tsu, L.Y., Hsu W.L and Wu, S. H, "A Cognitive Student Model – An Ontological Approach" ICCE'02, Auckland, 2002.

VanLehn, K., Siler, S., Murray, C. & Bagget, W. (1998). What makes a tutorial event effective? In: M. A. Gernsbacher & S. Derry (Eds.*) Proceedings of the Twenth-first Annual Conference of the Cognitive Science Society*, Hillsdale, NJ: Erlbaum. pp. 1084-1089.

Van Elst, L., & Abecker, A. (2002). Ontologies for Information Management: Balancing Formality, Stability, and Sharing Scope, *Expert Systems with Applications*, vol. 23, pp. 357-366.

Von Krough, G., Ichijo, K, & Nonaka, I. (2000). *Enabling Knowledge Creations: How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation,* New York: Oxford.

Vasconcelos, J., Gouveia, F., & Kimble, C. (2002). An Organizational Memory Information System using Ontologies. *Proceedings of the Third Conference of the Associacao Portuguesa de Sistemas de Informacao*, Univeristy of Coimbra, Portugal.