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Problem solving and knowledge inertia

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Abstract

Knowledge is becoming much more important for individuals and organizations than before. Knowledge management (KM) has been proposed as a methodology that can manage knowledge in organizations. However, KM may also have a nature, knowledge inertia (KI), stemming from the use of routine problem solving procedures, stagnant knowledge sources, and following past experience or knowledge. It may enable or inhibit an organization's or an individual's ability on problem solving. In order to explore to what extent, this research investigates several issues. First, types of knowledge have been specified. Second, knowledge from problem solving has been classified and understood. Third, inertia from knowledge is illustrated with some cases. Fourth, circulation of knowledge types in terms of avoiding KI is described. Finally, a case study of a military training institute implementing training revolution and overcoming KI is demonstrated. The proposed knowledge-based architecture investigates the mechanism of case base, heuristic base, and rule base that incorporates explicit knowledge, tacit knowledge, and procedural knowledge in support of managing knowledge and dealing with inertia. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Problem solving; Knowledge management; Knowledge inertia; Artificial intelligence; Theory

1. Introduction

In physics, the *principle of inertia* states that objects continue in a state of rest or of uniform motion unless acted upon by forces. Unless interrupted, an object's motion is subject to physical constraints and objects will move in the predicted trajectory. Humans can track and reach moving objects by predicting where objects are going. This truth suggests that human cognition also has inertia (Hofsten, Vishton, Spelke, Fent & Rosander, 1998; Kavcic, Krar & Doty, 1999). The whole procedure explains several things. Firstly prediction is based on that there is a trajectory *if* objects move *then* we can track and reach them according to their inertia. Secondly, changes in moving trajectory only happen if objects are interrupted by outside forces. It means that change of inertia is caused by an outside reason. Thirdly, change is not instinctual, but is forced.

In system logic programs, there is a *commonsense law of inertia*, which states that things do not change unless they are made to. The fact that revision programming is easily captured in logic programs using such inertia rules help to clarify the nature of revision captured programming. It provides a crucial element of proposals for representing knowledge about actions in default logic and logic programming (Przymusinski & Rurner, 1997). In human cognition, there is an *explanation process*, which derives something from a view of understanding that the other thing has been done (Schank, 1986). For example, as we read a text or listen to a discussion, we use our knowledge about what is being written or talked about to help us tie together the pieces of what we hear. Our past knowledge helps us predict what we will hear next, disambiguate words, resolve pronouns, and make connections between the disparate things being talked about. It implies that our past knowledge of what happened in something allows us to infer a similar thing and to explain it (Kolonder, 1994).

Usually, we are either right-handers or left-handers due to habits and experiences as infants. This physical inertia could keep us used to use it for our whole life and is hard to change. Is there evidence to show that a similar phenomenon, such as inertia, exists in knowledge use? Both in individuals and organizations, a high degree of the solution of a problem is generated by the knowledge acquired from past experience and its extension to fit new situations (Sternberg, 1985). People use a memory of past experiences and knowledge as a guide to generate planning for new problems. Re-use of past knowledge to solve a new problem becomes a law or principle that similar things continue in a state of remaining static or uniform unless it is not workable and then they are changed by outside forces.

Knowledge is becoming much more important not only for organizations, but also for individuals. Knowledge management (KM) has been proposed as a methodology that can manage the knowledge of the organization.

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However, KM may also have a nature, knowledge inertia (KI), stems from the use of routine problem solving procedures, stagnant knowledge sources, and following past experience or knowledge. It may enable or inhibit an organization's or an individual's ability on problem solving. In order to explore to what extent, KI enables or inhibits KM, the influence of inertia on knowledge use is interesting and necessary. This paper reviews existing artificial intelligence literature and investigates the issues of what is knowledge? What is knowledge for problem solving? What is knowledge versus inertia? Finally, a case study of a military training institute and a proposed knowledge-based architecture for managing training knowledge and dealing with inertia incorporating a rule base, a heuristic base, and a case base function are presented.

2. Knowledge and management

2.1. Knowledge

Knowledge is both power and resource for organizations. However, what is knowledge? How to specify knowledge? What are the types of knowledge? Knowledge can be viewed both as a thing to be stored and manipulated and as a process of simultaneously knowing and acting—that is, applying expertise (Blackler, 1995; Lave, 1988). Knowledge can also be represented as tacit or explicit (Polyani, 1997; Romer, 1995). Knowledge may be inherently tacit or seem tacit because no-one has yet articulated it, usually because of social constraints (Davenport, Eccles & Prusak, 1992; Schein, 1992). Tacit knowledge is subconsciously understood and applied, difficult to articulate, developed from direct experience and action, and usually shared through highly interactive conversation, storytelling, and shared experience. Tacit knowledge is of a more personal nature, involving such intangible factors as personal belief, and embedded in individuals (Hedlund, 1994; Nonaka & Takeuchi, 1995). This type of knowledge is the more compiled knowledge, and it is harder to extract this knowledge and formalize it in a knowledge repository (Liebowitz, 2001). In contrast, explicit knowledge is more precisely and formally articulated, although removed from the original context of creation or use (Zack, 1999). This type of knowledge is another type of knowledge that is more obvious and can be more easily documented. Internalized knowledge is how explicit knowledge is internalized, shaped, or influenced by one's own views and, therefore, may take a different form from one person to another (Liebowitz, 2001). Explicit knowledge is also called public knowledge, since it covers some aspects of knowledge that can be articulated in a formal language and transmitted among individuals.

Knowledge can also be specified from the general to the specific (Grant, 1996). General knowledge is broad, often publicly available, and independent of particular events. This is because the context of general knowledge is commonly shared with some other events. Specific knowledge is context-specific. It is meaningful across an organization and represents the specific context with some form of document, image, graph, object, and vocal expression. This kind of specific knowledge is a generalized knowledge to all members of an organization, or even a common language to shape the culture of that organization. Knowledge can also be categorized into three types as declarative knowledge, causal knowledge, and procedural knowledge. Declarative knowledge is about describing something. Shared categories and descriptors lay the foundation for effective communication and knowledge sharing in organizations. Causal knowledge is about why something occurs. Shared explicit causal knowledge, often in the form of organizational stories, enables organizations to coordinate strategy for achieving goals or outcomes. Procedural knowledge is about how something occurs or is performed. Shared explicit procedural knowledge lays a foundation for efficiently coordinated action in an organization (Anderson, 1985; Zack, 1999).

2.2. Knowledge and management

The last decade has demonstrated a rapid increase in the development of KM. A recent review of the literature shows that KM has been introduced in a variety of problem domains that range from theoretical research (Heijst, Spek & Kruizinga, 1997; Johannessen, Olsen & Olaisen, 1999; Liebowitz, 2001; Wiig, 1997), methods and techniques (Malhotra, 2001; Nonaka, 1994; Wielinga, Sandberg & Schreiber, 1997; Liebowitz and Wilcox, 1997; Nissen, 1999; Wiig, Hoog & Spex, 1997, and management activities (Anderson, 1996; Davenport, De Long & Beers, 1998; Davenport, Jarvenpaa & Beers, 1996; Lorentzos, Yialouris & Sideridis, 1999; Nonaka, 1994; Weber, Aha & Becerra-Fernandez, 2001). Most of this research illustrates the reason why organizations need KM and how organizations benefit from KM. However, some research focused on what kind of difficulties will surface in KM. This paper investigates research issues from artificial intelligence aspects on the following. Does knowledge have inertia? Does KM have limit? What kind of reason of KI could enable or inhibit KM?

In the case of organizations and organizational boundaries, inertia is created by existing data collection, systems, perceptions, expectations, and fears about how the data will be used (Herbsleb & Grinter, 1998). Organizations also develop routines for using certain information in certain ways, as they work with customers and technology regimes. These routines lead to the barrier of inertia, which can inhibit learning about markets (Adams, Day & Dougherty, 1998). People in organizations tend to act in a situated manner and employ organizations, plans, and software systems merely as tools that may or may not be used (Suchman, 1984). Interdependencies between group collaboration and

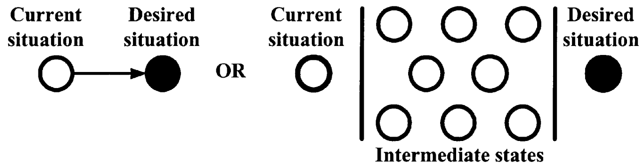

Fig. 1. The initial state of problem solving.

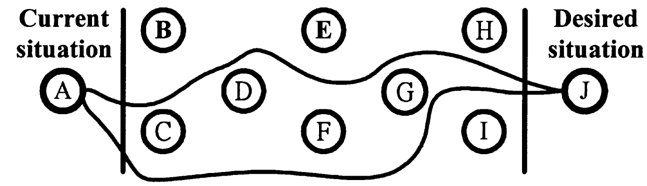

Fig. 2. Problem solving with a heuristic pattern.

organization facets also have their inertia (Michelis, Dubois, Jarke, Matthes, Mylopoulos, Schmidt et al., 1998).

A recent article investigates what is the merit of the ideas underlying KM and extends a concept of 'sharing knowledge is power' (Liebowitz, 2001). Supposed knowledge is fluid like water and it circulates through both individuals and organizations in terms of problem solving; once knowledge is no more shared and updated with individuals and organizations, then stagnation of water could cause the water death and the loss of its nourishment. It means that updating knowledge is the source of power to keep knowledge cultivating and enriches the abilities of KM on problem solving. Artificial intelligence can bring improvement to individuals' and organizations' ability to promote knowledge sharing (Liebowitz, 2001; Weber et al., 2001).

3. Problem solving and knowledge

In a dynamic environment where the state of the domain is constantly changing and evolving, problem solving involves the transformation from one temporal stable state to another state, which is normally caused by an event or a chain of events. It is impossible to model all conceivable internal and external events that may cause changes in the problem domain. Therefore, past experience or knowledge can be used as an aid for considering the situation, generating plan(s), making decisions, and obtaining the results of problem solving that we have done.

During the process of problem solving, the solution to problems is always generated by the knowledge acquired from past experience and extended to fit new situations. Depending on the nature of a problem, different types of knowledge can play different roles in aiding the problem solving process because the solution for simple problems or complicated problems is conducted differently. This research investigates the knowledge types of problem solving in terms of describing the relationship between problem solving and knowledge.

3.1. Problem solving with explicit knowledge

With a new problem, the initial state of problem solving is to assess the current situation and to identify a desired situation where the problem can be solved. Once both current and desired situations are identified, there are two possible conditions of problem solving. One of the conditions is that the distance is very clear between the current situation and the desired situation. It is easy to know how to get to the desired situation. In contrast, the whole picture of problem solving and the distance between the current and the desired situations is sometimes vague with some uncertainty in intermediate states. Therefore, the main purpose of this state is to identify the intermediate states between the current and the desired states, which are shown in Fig. 1.

If it is very clear to identify how to reach the result from the current situation to the desired situation, then the method for solving a problem is explicit (left-hand-side pattern in Fig. 1). It means that there is a rule existing in the process of problem solving from past knowledge and it can be used as a knowledge aid to solve a similar problem next time. If a method in the problem solving process can be represented as a specific form or rule, this knowledge can be codified as explicit knowledge. The relationship for problem solving between the current and the desired situation can be described as:

Rule: Current situation → (Specific knowledge) → Desired situation.

3.2. Problem solving with tacit knowledge

In fact, at this initial stage, what knowledge involves in problem solving is aid and supports in the form of dealing with what to do and how to do it. If a specific problem is new and complicated, it is not always clear to describe how to solve the problem; it is even hard to identify the desired situation precisely. People often do not have an overall picture of problem solving including the initial and desired situations (right-hand-side pattern in Fig. 1), but based on their experience, knowledge on short-time decision or under the guidance of some heuristics obtained from past knowledge in similar problems. Sometimes, with a new problem, knowledge is not good enough to offer the source of a solution. Because of the limit of deep insight, knowledge has its gaps in different situations even in the same problem domain. Past knowledge, experience or heuristic knowledge, may give a clue to make an analogical reasoning as a knowledge aid to a new problem; however, the knowledge among intermediate states is not always the same as the past.

Due to past knowledge, some patterns offer clues to illustrate how to reach the desired situation from the current situation. This pattern is not explicit, but tacit or general, which acquires knowledge by referencing used images, diagrams, patterns, or formations. Mostly, the pattern for

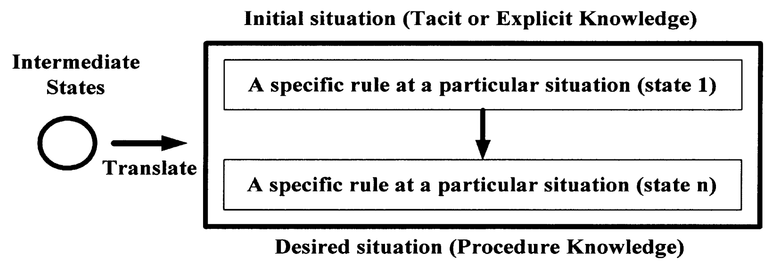

Fig. 3. The translation of intermediate states in the problem solving process.

problem solving is different from the others with different personal subjective evaluation. In Fig. 2, the pattern for problem solving includes some intermediate states; however, the solutions or paths among these states are not visible. If a set of possible rules in the problem solving process can be represented as a specific pattern or formation, this knowledge can be represented as tacit knowledge. The heuristic knowledge of the pattern {A, J} can be described as {State A, State C, State D, State F, State G, State J}. Without connected paths, the solution from heuristic knowledge gives strategic guidance to show the whole picture of the problem solving.

3.3. Problem solving with procedure knowledge

Procedure, which represents specific knowledge tied to specific situations, represents knowledge at an operational level. That is, it makes explicit how a task was carried out or how a piece or knowledge was applied or what particular strategies for accomplishing a goal were used. For example, in the case of case knowledge, any case in the case base is composed of three major parts, which are problem descriptions, solutions and outcomes (Kolonder, 1994). Description is the main method for identifying the problem, which includes the current situation and the desired situation. Solution is the chain of intermediate states or rules, which illustrates the procedure how the problem was solved. Outcome is the result, which shows the result of the problem being stored and referenced.

As shown in Fig. 3, experience and knowledge will be used in developing solution methods at particular situations to achieve the intermediate states in terms of solving the problem. This process involves an issue about what and how knowledge aid is implemented in the problem solving process. Then, the process of problem solving is translated state by state. In the initial situation, tacit or explicit knowledge is the source in terms of identifying the problem and describing the details of problem solving. However, with the chain of intermediate states, the problem solving process is connected with rules, states, and patterns. Once the desired situation is achieved, complete procedure knowledge from problem solving is demonstrated.

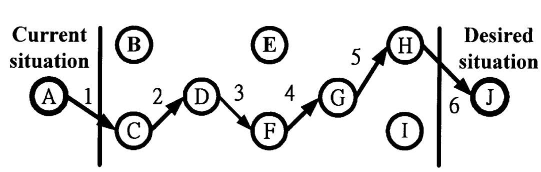

Fig. 4. Problem solving with a chain of intermediate states.

The lines in Fig. 4 indicate the chain of translation among intermediate states. In translation, only two states are presented in the chain, as the means of working out the best possible method of translating state A to state C with the knowledge one. If a formation in the chain consists of two achieved states from current situations to {A, D},

Objective 1: prescribes state A to translate at state C.
Objective 2: prescribes state C to translate at state D.

Then,

Rule 1: State A → (Knowledge 1) → State C.
Rule 2: State C → (Knowledge 2) → State D.

Then, the fully connected chain of intermediate states for problem solving is shown as follows if the desired situation is the ultimate objective state.

Problem solving: State A → State C → State D → State F → State G → State H → Stage J.
Problem solving knowledge: Rule 1 → Rule 2 → Rule 3 → Rule 4 → Rule 5 → Rule 6.

Comparing with Fig. 2, the tacit knowledge and detailed solutions from connected rules are different from the pattern of heuristic; it means that knowledge has its gaps in different hierarchies even in the same problem domain. Until the desired situation is reached, the knowledge of problem solving is not complete. We can conclude the procedure knowledge of the problem {A, J} as:

{State A → (Rule 1) → State C → (Rule 2) → State D → (Rule 3) → State F → (Rule 4) → State G → (Rule 5) → State H → (Rule 6) → State J}.

Explicit knowledge is the functionality of knowledge aid with rule-based method. Solution to problem solving belongs to the attribute of specific knowledge. Tacit knowledge is helpful in solving problems by matching analogy knowledge from heuristic patterns or formations and is

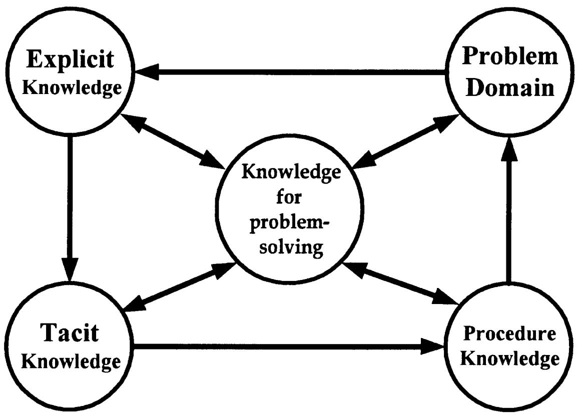

Fig. 5. Knowledge and problem solving.

attributed to general knowledge. Procedure knowledge is aggregate with rule and heuristic knowledge and is a kind of case knowledge as well.

From a micro to a macro perspective, explicit knowledge is the baseline to illustrate how to reach the result of the problem solving. Tacit knowledge is the clue to problem solving with concise knowledge. It is encoded in a set of problem solving rules or forms. Procedure knowledge is a complete knowledge that demonstrates what or how to solve the problem. It is codified with rules and heuristics in terms of interpreting accumulated knowledge content in a specific problem domain. The circulation of knowledge at a specific problem domain is shown in Fig. 5.

4. Knowledge and inertia

When we are used to solving problems or dealing with something repeatedly with the same method, it can infer a similar thing and explain it with similarity matching and analogical reasoning in terms of saving time to think and avoiding risk of change. However, if everything comes from past experience and knowledge without revision and update, the method for problem solving will be predictable and inertial. Once, in a highly competitive environment, someone predicts the trajectory of what you are thinking or doing, tracking and reaching of predictive action from others could cause failures and loss. This research investigates the relationship between knowledge and inertia in terms of exploring the extent to which inertia of knowledge enables or inhibits KM.

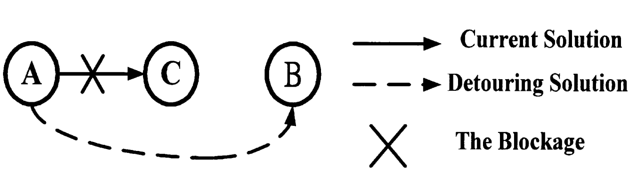

Fig. 6. The revision of inertia with detours.

4.1. Inertia from explicit knowledge

Explicit knowledge, mostly, comes from documents, books, academic references, and sources from a specific problem domain that has been communicated, examined, approved, and tested. Explicit knowledge can be represented by rules, which illustrate the variety of inference tasks supporting on matching the problem and generating plan(s). Each step and rule of a specific knowledge, with the aspect from artificial intelligence, can be demonstrated as the semantic structure of *IF A THEN B* (Schank, 1986). In the problem domain of knowledge-based systems (KBS), the first step of *IF* is problem understanding and the next step is to propose a solution. This inference procedure of rule is the baseline for educating, learning, and problem solving.

The traditional approach to the development of (KBS) was rule-based (Xu, 1996). A rule-based system needs a well-constructed domain theory as its inference basis (Lorentzos et al., 1999). A well-constructed inference basis is usually implemented and valued according to its technical merits although its capability may be limited when previous single knowledge is not a good representation of the whole population. It may contain knowledge use because of a rule in any expertise area in relation to specific events and time is limited to its nature of learning and creation. When knowledge is explicit or specific, it represents and exists in an embedded way in the system or organization. However, once the rule knowledge is embedded, can knowledge be changeable or extendable?

As shown in Fig. 6, the solution fails to work translating from state A to state C and knowledge aide from the past rule becomes unfeasible. For example, we all have similar experience to keep dialing a telephone number many times when the line is busy and this response will remain inertial action until the reality changes. Sometimes, we are not trying to go around, or under the blockage, or even to stick into fixation at a specific situation (French & Caplan, 1978). Detour means finding other workable solutions to reach any results in the original state by bypassing and avoiding the blockage. This implies revisions to remedy the solution as shown in Fig. 6 (from A to B). Blockage here is the result if inertia continues to translate from A to C. Revision and modification could make the solution workable again and generate new knowledge from problem solving.

4.2. Inertia from tacit knowledge

With new problems, we often use a kind of analogical reasoning for the assessment of the problem. Analogical reasoning is a mechanism used to extend knowledge to a particular problem that is, on the surface, unfamiliar by using relations contained in problems which are well understood and which have been solved (Marchant, 1989). This analogical reasoning, heuristic reasoning, is like ‘structure

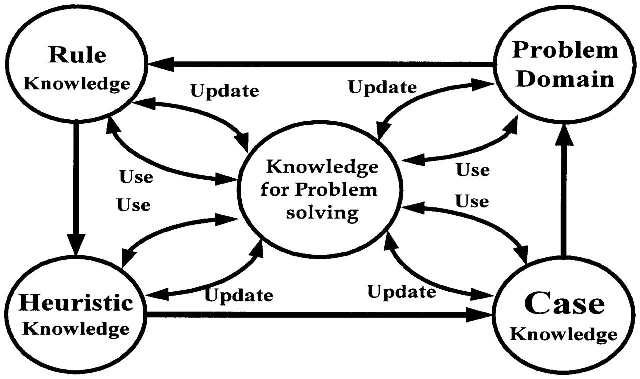

Fig. 7. The circulation of knowledge for avoiding knowledge inertia.

mapping', where identical relations among different objects are mapped. The mapping process involves matching for a set of one-to-one correspondences based on the similarity of propositions at a specific level of abstraction, pattern, and formation. However, this mapping process is distinctive among others and belongs to abstract, intangible, and tacit knowledge.

In general, the common way adopted by most humans dealing with problem solving in a dynamic environment is by initially matching for similarity (Kolonder, 1994). Pattern matching or recognizing both the current and desired positions associated with a possible and pre-used plan is from past experience or knowledge. The details of the plan may not be very clear or available at the very beginning stage; however, it does provide a framework and direction to find a plan path. Once a plan is recognized, what one has to do is to activate the plan and follow it from start to finish no matter whether the result is perfect or not. This procedure, tacit knowledge, can offer a clue or episode to decision support or problem solving among each possible plan path with concise knowledge. An example is the case of traveling on the underground transportation networks; walking into a station, picking a destination, taking the correct line, and changing line at specific station(s) when necessary. All of these actions are achieved almost entirely by recognition without in-depth reasoning.

In contrast, in the case of military officers, because of military specialty from different military branches, research results show that different military branch officers do have preferred strategy and tactics in terms of employing their military knowledge in a game-play test. Military officers are used to solve a problem by using some sort of heuristic knowledge of military combat formations or patterns deduced from their past working experience and training (Liao, 2000). Therefore, a human-oriented problem solving methodology uses heuristics to identify the possible linkages among plans.

4.3. Inertia from procedure knowledge

Most of the procedure knowledge for problem solving is implemented in the standard operation procedure (SOP). SOP is a process that embeds necessary routine works to operate or maintain the operation at a specific task or organization. To a specific problem, from initial to desired situation, a problem solving procedure associates a sequence of workflow and all activities are summarized in some sort of knowledge content. This kind of knowledge is always implemented in organizations.

From the examples of history, failure of organizations, which comes from inertia, happened repeatedly. In the case of military history, during the Second World War, according to past war experience, the Alliance military could not have a chance for landing on the area of Normandy successfully under bad weather and tide. The German military commander and staff made this prediction and prepared their main forces to engage the Alliance on the northern coast of France. Of course, we cannot ignore the truth that the Alliance military deceived the enemy with some activities before the landing operation was implemented. It confused the German judgment and they made a wrong decision. However, most military historians and instructors will agree that the German military was over-depending on past war experience and knowledge to predict the motion of the Alliance. It caused great loss on further military strategic operations and time was wasted in moving a great amount of troops to the wrong place. In contrast, the Alliance military predicted German motion precisely that the Normandy landing was an unexpected and an impossible action for crossing the Channel. Another example on this issue is the Korean War, Inchon Landing. Inchon Landing was, indeed, not a traditional reasoning deliberation from conventional military knowledge. The operation of surprise and deception took precedence over the risk and inertia in its military implementation so much that it created a victory.

If KI exists in organizations, then what do the organizations do? During the last couple of years, KM in organizations has grown rapidly. Several different theories and aspects of AI have been developed, such as: knowledge-based systems; business procedure re-engineering; corporate memories; conceptual framework; case-based reasoning; and expert systems for extending the capabilities of innovation, creativity, communication, and learning into organizations (Adams et al., 1998; Heijst et al., 1997; Johannessen, Olsen & Olaisen, 1999; Malhotra, 2001; Weber et al., 2001; Wielinga, Sandberg & Schreiber, 1997; Wiig et al., 1997). In considering the problem of KI, this paper extends the concept of 'sharing knowledge is power' and investigates whether updating knowledge is the method for avoiding KI.

Fig. 7 investigates how KI is created from past experience and knowledge without update and may inhibit new knowledge circulating to individuals or organizations in terms of solving new problems. Artificial intelligence techniques, such as: rule-based; heuristic-based; and case-based are frequently implemented on KM (Liao, 2000, 2001). However, inertia of knowledge sometimes causes in some cultures that no-one would share their knowledge with others without incentive or reward systems to motivate the knowledge sharing process. The circulation of knowledge for avoiding KI depends on building supportive culture or necessary inside or outside force to make it work. This paper presents a case study of a military training institute to explore the content of military training in problem solving and KI. This case study demonstrates how a military organization succeeded in implementing artificial intelligence techniques on training revolution and KM.

5. A case study of a military training institute in problem solving and knowledge inertia

The necessity of training problem solving skills has been recognized recently (Bettenhausen & Murnighan, 1985; Cannon-Bowers, Salas & Converse, 1993). These skills are crucial for both individuals and teams to be able to cope with the dynamic environments of today's world (Baxter & Glaser, 1997; Orasanu & Connolly, 1995; Oser, Cannon-Bowers, Dwyer & Miller, 1997). Some research works enact systematic approaches that present knowledge, demonstrate concepts, initiate practice, and provide feedback (Cannon-Bowers & Salas, 1997; Dwyer, Oser & Fowlkes, 1995). The above review provides the importance of training problem solving. Military training is a problem solving methodology, which combines the functions of analysis, planning, decision-making, and execution into the process of a specific military problem domain. Also, to a military officer, military training is a source of knowledge acquisition and an environment to support the process of decision-making and problem solving.

In implementing the domain of this research, problem solving and KI, this paper presents a case study from the Institute of Strategic Defense Management in Taiwan, in terms of demonstrating how it implements its military training for problem solving and avoids the possibility of KI. A knowledge-based system architecture of ISDM for managing and updating training knowledge by incorporating the function of rule base, heuristic base, and case base in terms of avoiding KI is presented.

5.1. What does the Institute of Strategic Defense Management do?

The Institute of Strategic Defense Management is a part of the National Defense University, Management College, in Taiwan. ISDM is responsible for educating selected military officers for senior (strategic) and intermediate (staff and command) leadership positions through teaching and research dealing with the national defense resource management, with special emphasis on logistics and defense planning. The institute is also authorized to develop defense management-related course materials, doctrines, and regulations, and to improve the qualities of defense police decision-making through advanced studies, analysis, and counseling.

Student Officers who are selected to participate in the training course of ISDM conduct intermediate and senior level courses of study with the required knowledge of human resources, material resources, finance, and information management, which can be extended into the advanced national and military training programs. The training period of each course is one year and each officer is enrolled into one of the professional teaching groups (manpower, logistics, finance, information & communication, and procumbent professional groups). Officers whose military rank is higher than major (including colonel) are qualified to join in the open contest of entrance examination every year.

5.2. What problem does Institute of Strategic Defense Management have?

The Institute of Strategic Defense Management was founded in1978. The institute is the main training class in terms of training military financial, logistics, administration, and engineering officers in Taiwanese Military. It is a long time for this Institute to remain stagnant conditions that training materials, methods, courses, and instructors are not updated or rotated. Until the last couple of years, the institute faced great pressure of change from inside and outside.

In the 1990s, Taiwan purchased the third generation weapons system from USA and Europe. Also, in the beginning of the 21st century, Taiwanese Military was involved in the concept of Revolution in Military Affairs (RMA) that implements modernized concepts and methods to make the military operation more efficient. In the meantime, National Defense Act and National Defense Organizations Acts were published in terms of implementing the re-engineering of military organizations. Due to the above developments, it was a great challenge for ISDM to accomplish the mission of officers training. Because instructors were not rotated, training methods and materials were not updated, old training experience and knowledge (include training culture) were not good enough to satisfy the needs of student officers and military organizations. Therefore, inertia of the institute caused by not updating and learning itself with the changing environment became a problem to ISDM.

Due to the outside needs, the Commandant of National Defense Management College and Director of ISDM were determined to make changes and revolution in terms of reconstructing the organization and course structure. Firstly, instructors were selected from the Military whose quality was satisfied with both military practice and academic degree (masters or PhD degree). Secondly, some instructors were sent abroad to accept short-time training on Alliance military institutes or civilian universities in terms of developing new courses. Thirdly, old courses were redesigned and information systems were implemented into the training

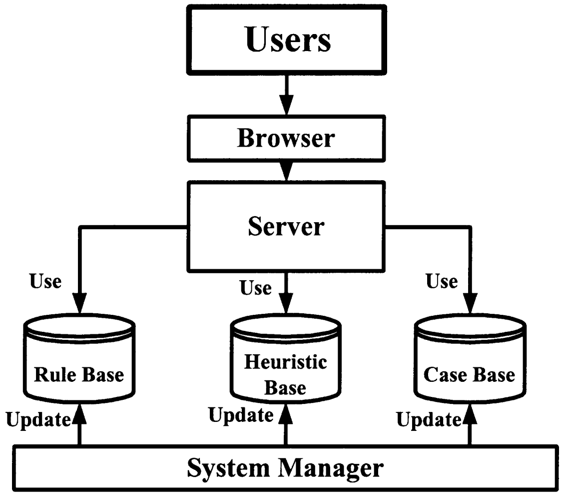

Fig. 8. The system architecture.

mechanism for incorporating training materials, response, experience, and knowledge from student officers and instructors. A paperless electronic training environment was developed and more users were accessed as to what they needed and what they think on the net. Fourthly, database and knowledge base of these training systems were opened to military organizations or troops in terms of obtaining more support and updating more practices, comments, and suggestions from outside. The Institute was transforming its role from a training unit to a think-tank in the Taiwanese Military. All efforts helped solve the problem of inertia on the military training institute from past barriers and developed new vision to the future. This training revolution project of ISDM has proceeded for four years since 1997.

5.3. Knowledge-based architecture of the Institute of Strategic Defense Management

5.3.1. Intranet-based system configuration

The Institute of Strategic Defense Management constructed an Intranet-based system configuration. Compared to traditional forms of information access, an Intranet-based information system access provides several advantages, such as: more variety; larger volume; and greater reach. These advantages allow greater exploration of issues relating to problem solving. This can be of immense value to problem solvers especially when dealing with semi-structured or unstructured problems (Sridhar, 1998). A web-based system is an easy-to-use interface, offering support for heterogeneous computing platforms and relatively low costs have been gaining widespread acceptance. This is rapidly leading to new ways of using, sharing and managing information in most organizations.

As shown in Fig. 8, the system architecture utilizes three kinds of function bases that include rule base, heuristic base, and case base. Users can use a browser to access function bases from the server. This Intranet-based system configuration enables each function base to operate with others independently. This configuration can also access more information in the same time, and the distribution to different users can be accessed from any location linked to the Intranet. In terms of avoiding KI, data or knowledge without update, the system manager is designed to update the content of function bases. It provides the mechanism that both student officers and instructors of ISDM can create, share, communicate, and update any new valuable material into the function bases for updating knowledge on systems from time to time.

5.3.2. Rule base

Rule knowledge is a kind of explicit knowledge. Military principles, guidelines, handbooks and general management textbooks support rule base. Rule is the baseline for student officers to learn new things with a specific knowledge in a specific problem domain. Usually, student officers can prepare by referencing the rule base on the net for what kind of materials are necessary to a specific training course before they get into the classroom. An abstract or electronic file of reference materials is set up on the rule base for supporting the function of rule base.

5.3.3. Heuristic base

Compared to rule knowledge, heuristic knowledge belongs to the range of tacit or general knowledge. Sometimes, experience or expertise is subconsciously understood and codified, and is difficult to read with materials. Instructors are responsible for interpreting their experience and knowledge from heuristic status to a designed course. In Fig. 9, every instructor has organized his teaching materials, for example: presentation files; reference papers; technical reports; and long distance teaching files (under construction) on the net with the index of course title. The content of heuristic base is updated annually and is a part of instructor performance evaluation.

5.3.4. Case base

Case is a kind of procedure knowledge; that is, it makes explicit how a task was carried out or how a piece of knowledge was applied or what particular strategies for accomplishing a goal were used. Any case knowledge in the case base is composed of three major parts, which are problem description, solutions, and outcomes (Kolonder, 1994). Case studies or scenario training are used as a main method for training military officers in class for analyzing situations, generating plans, making decisions, simulating organizational teamwork, and exchanging knowledge/experience from the training procedures. This is the most important part of a training course. Comparing the content with rule and heuristic knowledge, case knowledge is neither static nor unchangeable. Every main course is a designed case study or scenario training after theory

Fig. 9. The design of heuristic base.

teaching by the instructors. Any new originality, idea, and creativity of problem solving to the case study or scenario are updated for case learning. New case knowledge is the main criterion to re-examine if a rule or heuristic knowledge is still reasonable to a specific problem domain. It is possible for student officers to reconsider the past knowledge and for instructors to update or modify the knowledge of rule and heuristic bases. Then, new military doctrines or principles could be published in terms of replacing old materials. In Fig. 10, case base hierarchy is designed as the structure of curriculum and case indexes can be retrieved with the case number of course title.

5.3.5. Learning

After the implementation of case study or scenario

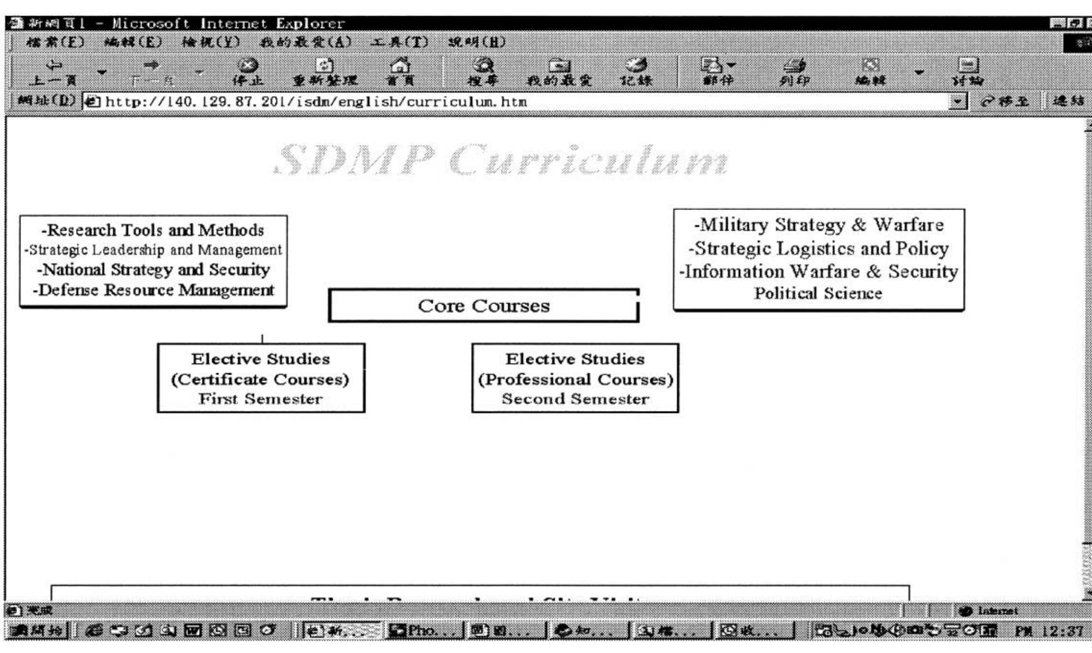

Fig. 10. The design of case base.

training, the instructor is often open to student officers for discussion. When all questions, discussions, and debates are finished, the learning functions of student officers and systems are implemented. Firstly, student officers learn some experience and knowledge of military expertise, and how to solve a problem by cooperating the military organization and mechanism and operating the procedure to a specific designed case or scenario. These cognitive processes and skills are critical for military training, problem solving, and for avoiding KI. Secondly, to the system, in the theory of case-based reasoning, at the end of each problem solving session, the case memory is updated with a new case. It is then important to identify any important difference among the old cases that may be useful to our knowledge for problem solving in the new case. Then, it may be recorded as a new case for learning (Kolonder, 1994).

Additionally, a knowledge sharing culture needs to be created to include an incentives/reward system to motivate others to share their knowledge. Building this supportive culture is critical in the possible success of a KM initiative (Liebowitz, 2001). In ISDM, the policy following system implementation, updating value knowledge from student officers and instructors is the main credit index for evaluating training and teaching performance. This policy is strongly supported by the Commandant and Director. In Fig. 8, this is the objective of ISDM for constructing the knowledge-based system architecture. The proposed system architecture is implemented into the military training mechanism that integrates rule base, heuristic base, and case base into the circulation of training knowledge for avoiding KI. Therefore, the more the case (scenario) development and training, the more the knowledge could be of value to the training institute while less KI would occur. However, the system is still under extension (long distance teaching and database systems update) and evaluation of student's and instructor's attitudes on the training revolution process is not designed to test.

6. Summary and future work

This is a preliminary research on the topic of KI. Several issues were considered in this paper. First, types of knowledge have been specified. Second, knowledge from problem solving has been classified and introduced. Third, inertia from knowledge is illustrated with some cases. Fourth, circulation of knowledge types in terms of avoiding KI is described. Finally, a case study of military training institute in problem solving and KI is demonstrated. This case study demonstrates how a military organization succeeded in implementing artificial intelligence techniques on training revolution and KM.

KI is not totally bad on KM; it may enable or inhibit an organization's or an individual's ability on problem solving. However, it depends on whether sharing and updating knowledge could be supported and implemented. The case study shows how a military training institute causes an inertia problem due to the reason of stagnant knowledge source. It also demonstrates that the organization needs supportive culture and incentive system to create KM environment in terms of updating and sharing knowledge even the force of change is from inside or outside. The proposed knowledge-based system architecture presents the mechanism of case base, heuristic base, and rule base that incorporates explicit knowledge, tacit knowledge, and procedural knowledge in support of managing training knowledge and dealing with inertia.

Several recommendations for future work and research could help to explore the KI, not only the concept of artificial intelligence, but also its usefulness in KM.

First, a well theory and methodology needs more sophisticated rules, cases, and models to test and prove. KI, or similar concept, in this paper still belongs to preliminary research. It is the research limits on this paper that KI Concept is not completely tested and investigated with different theories, methodologies, and techniques.

Second, KM is a broad research topic. However, this paper shows that the gaps of whole picture of the research topic have not been explored. Human reasoning, cognition, information processing, and artificial intelligence are different sources of theories and methodologies to explore KI in terms of concluding concrete suggestions to individuals and organizations.

Third, military organizations differ from private organizations due to the nature of organization attributes. A supportive culture of sharing knowledge is a different example, not only on organization culture, but also on incentives/reward system. It needs more evidence and examples to show updating knowledge is helpful to deal with KI.

Fourth, the characteristics of the knowledge types that lead to KI need to be more examined. Statistical analysis of factors and variables in KI can provide more suggestions for how organizations can use and explore the concept of KI.

Finally, AI techniques in this research are a minority. It is hard to present the merit of this research topic. It may, indeed probably should, implement more techniques to investigate if KI is actually good or bad to a specific type of organization.

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