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Philosophical foundations for a learning-oriented knowledge management system for decision support

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Abstract

Traditional organizational and support structures no longer function efficiently in the face of increasingly complex problem domains because these structures are generally not conceived from the social perspective, requiring development of new organizational structures and support systems. These structures must be able to support traditional decision-making in an increasingly complicated social domain. This paper defines the concept of an inquiring organization and conceptualizes a learning-oriented knowledge management system (LOKMS) for that type of organization. The role of the learning-oriented knowledge management system for inquiring organizations, which includes decision-making and learning process support, is discussed.

Keywords: Decision-making; Organizational learning; Knowledge management

1. Introduction

Businesses today often find themselves in a new environment, one that is increasingly service oriented. They are realizing that discovery and maintenance of knowledge is critical to surviving in the new knowledge-based economy [29,45] where interactions with customers and clients play increasingly important roles in the long-run success of the firm. This environment presents new problems to managers—ones that are increasingly socially oriented and therefore are at minimum ill or unstructured [32,41,44] and may be wicked [41]. Wicked problems contain a high percentage of unknown or uncertain variables and relationships, are difficult to define, and are highly subjective. Solutions to such problems often require that the decision-maker make "judgments of fact about the 'state of the system' both internally and in its external relations" [32]. Such environments not only require organizations to be able to make decisions effectively and rapidly, but also to be able to create knowledge and to learn.

Simultaneously, new types of organizational structures are emerging. Boundaries between and within organizations are not as rigid as they once were, and market and production competencies are being replaced with alliance capitalism and knowledge-

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based competencies [13,15]. Human resources and the intellect they possess are becoming acknowledged as a valuable resource [24]. As organizations recognize the advantages of intellectual capital and increased knowledge-based competencies that vertical integration or collaboration provides, relationships with other organizations are becoming stronger and more critical, requiring shared information among all stakeholders.

Organizations have begun examining the concepts of knowledge management and of organizational learning as ways to improve their operations. Zhang and Faerman [51] analyzed organizational learning and knowledge management literature and found that knowledge management is most often represented in technical domains such as expert systems, information systems, and artificial intelligence. Organizational learning, on the other hand, is represented in social domains such as organizational behavior, organizational theory, and psychology. These two disciplines have moved closer over time through a mutual understanding of knowledge and its origins, but neither has offered a comprehensive foundation on which to build [51]. Crossan et al. [12] argue that organizational learning research is rich in understanding but lacking in theory.

This paper uses the concept of an inquiring organization [11] to provide a philosophical theoretical context for the design of a learning-oriented knowledge management system (LOKMS). Building on the work by Hall et al. [17–21], this paper demonstrates how the modules and components inherent in Hall et al.'s model follow and support the seven-stage systems approach to decision-making [33].

2. Inquiring systems, inquiring organizations, and learning

Inquiring systems are characterized by the properties of the five inquirers described by C. West Churchman [8]. These systems have the ability to gather and model evidence in a way that represents the system's view of reality. Churchman ([11], see also Refs. [12,38]) describes five inquirers based on the writings of five Western philosophers—Leibniz, Locke, Kant, Hegel, and Singer. Among their characteristics are the use of feedback loops and temporal consideration during the decision-making process and their ability to incorporate many perspectives and generate multiple models based on those perspectives.

Unlike traditional support structures that are primarily concerned with choosing the best alternative for a given problem definition, inquiring systems provide support during all phases of decision-making (especially the problem definition phase itself) by encouraging member communication and allowing feedback throughout the decision-making process [20]. Inquiring systems also create and manage knowledge and provide a component called a guarantor that "guarantees" that the knowledge created by the system is not false [11,21,29]. Inquiring systems can provide the basis for a knowledge management support system that is capable not only of traditional decision support, but also of helping the organization learn by facilitating the creation of new organizational knowledge and the adaptation of existing knowledge in wickedly changing situations [11,21,29]. Inquiring organizations are based on the philosophies underlying inquiring systems [11].

An inquiring organization can use developments in technology to support the flexible nature of the inquiring system, such as using collaborative technologies to allow all organizational partners to share knowledge and information regardless of physical location. Additionally, these organizations can support utilization of their members' tacit knowledge by maintaining information on each member's area of expertise and by providing for communication between members of the organization. While providing the ability to maintain a central knowledge store, an inquiring organization can decentralize the decision-making process to intra- or inter-organizational group members who understand the problem at hand and can more quickly recognize a beneficial course of action. It is important to note that centralized used in this context means organizational memory that is available to the organization as a whole and does not imply a centralized database concept.

Inquiring organization and learning organization are terms that are often used interchangeably; however, there is one critical difference between the two. To be an inquiring organization, the organization's philosophical foundation must be laid on the principles of inquiring systems as discussed by Churchman [8]. Both the learning organization and the inquiring organization aspire to learn. However, an inquiring organization inquires, that is, it searches and investigates its environment, whereas a learning organization has adopted a learning style that is cognizant of the importance of learning. Learning styles can be categorized as loop learning. For example, an organization may alter its modes of behavior in response to changes in the environment (single-loop learning) or may seek to create new modes of behavior (double-loop learning). Generally, learning organizations engage in double-loop learning (such as changing organizational objectives to increase efficiency) [1]. Inquiring organizations often engage in triple-loop learning: behavior that examines the learning process itself with an end goal of increasing learning efficiency. In this manner, the organization challenges the assumptions on which its behavior is based, effectively examining not the most effective means to an end, but examining the foundation of means themselves [26].

Hawes [25] and Weick [49] suggested that an organization is more of a process than an entity, and thus, an organization should be considered a verb rather than a noun. Inquiring organizations epitomize the view that learning is the driving force behind the process [50]. In fact, the literature suggests that those conditions that must be in place for a problem to be solved—prior knowledge and experience of the individual and the sharing of that knowledge and experience between decision-makers—are the same as those that are required for learning [5,9,46].

Examples of organizations that have applied inquiring systems concepts to facilitate organizational learning are discussed by Richardson et al. [40]. Such organizational learning may be based not only on past performance review but on continuous review of available information and updating of models based on that information. This update process is one of the inherent functions of an inquiring system that supports organizational learning. Both information acquisition and problem definition are critical in the learning process. It is in this vein that the learning-oriented system described here excels.

3. Information acquisition

The role of information in an inquiring system is a complex issue worthy of a complete paper alone. For details, the reader is referred to Churchman [8] and Hall et al. [21]. However, for the purposes of this paper, information involves data in context. Information is not separate from its context because the interpretation of incoming data streams is dependent not only on the perception of the receiver, but in the context of the moment. Information that is relevant becomes actionable knowledge during the duration of the specific context. This is the reasoning behind the design of specific subcomponents to be introduced shortly. For an inquiring organization in particular, information is the critical piece that transforms fact into knowledge. On a philosophical basis, inquiring organizations are founded on axioms (undisputed facts) and "fact nets" that contain facts that do not dispute axioms [8] and from which information is drawn.

Information acquisition can be either proactive (a search for opportunities or needs that have not yet been recognized) or reactive (in response to an identified need or opportunity) [7]. Proactive acquisition can be initiated by an individual or by automated scanning technology. In proactive acquisition, the search will likely be less formal, although there may be some scope limitations in place. For instance, a sales manager may be interested in the promotions of competitors, but not in every aspect of the competitor's business actions. The scope (or lack of) is generally related to the resources available for information acquisition. Fewer resources typically result in searches that are more specific. Problem definition and formulation play an important part in all information acquisition, especially when resources are limited. Incorrect or incomplete problem definition may result in resources being spent on ineffective scans. Choudhury et al. [7] discuss the economic implication of resource allocation for environmental scanning. Discussed in the same article are the concepts of knowledge specificity and time specificity for information acquisition.

Knowledge specificity refers to information that can be acquired or used only by someone with specific knowledge and can be further divided into technical or contextual. Time specificity defines information whose value is dependent on the point at which it is acquired or used. The type of knowledge (or time) specificity that can be assigned to a specific information need is dependent on the problem (if defined), the set of possible problem sets (if no problem has been identified), and the experience of the individual who is acquiring or using the information.

When considering an individual who possesses knowledge and another who seeks to acquire the information from which to reconstruct that knowledge for personal use, either both individuals must possess the same tacit knowledge or the first individual must be able to communicate to the second individual enough information to allow that person to efficiently construct the knowledge. If the knowledge is procedural and explicit, this is not likely to be a problem because the second individual will not be required to interpret the information. If, however, the knowledge is primarily tacit, one organization member may not be able to communicate to another the required information that will enable that individual to effectively construct the knowledge. This problem becomes less evident, however, as the knowledge base grows to be shared by others and the organizational vocabulary becomes consistent.

Ultimately, the amount of shared knowledge within the organizational structure will affect knowledge specificity. The less sharing of knowledge in an organization, the more specific knowledge becomes. As an organization begins to share knowledge, specificity is reduced. In other words, the more knowledge is shared, the more potential it has to affect multiple decision domains in an organization, thus reducing its specificity. Inquiring systems, because of communication among members and the maintenance of a centralized knowledge base, help reduce knowledge specificity.

4. Problem definition

Organizational learning is hampered when problems are defined inappropriately, which may lead to the application of irrelevant organizational knowledge to a problem. Businesses need to act and react quickly in today's rapidly changing business landscape, and inefficiencies introduced by inaccurate problem formulation can lead to missed opportunities. Several articles discussing automated discovery in deep and narrow problem domains appeared in the 1980s [3,5,6,31]. Billman was successful in proving that her discovery module outperformed test subjects in correctly hypothesizing causal relationships, allowing for improved problem formulation.

Discovery continues to be of interest among researchers, especially as data warehousing and data mining are becoming more mature technologies. Data mining is an effective acquisition tool and is particularly adept at discovering relationships or patterns in data, which is the essence of discovery [39]. Research has demonstrated how eliciting managerial expectations of relationships, and using those expectations to search for unexpected relationships [36], is a beneficial method of discovery.

Organizational learning is an important aspect of organizational growth and success. Unfortunately, the improvements in technology that allow for increases in information acquisition and sharing are also contributing to difficulties in managing the influx of information and therefore may negatively impact the propensity to learn. Traditional support for decision-making has been an effective part of decision-making technology, but the needs of today's organizations are changing, and the technologies must change with those needs.

5. The conceptual model of a learning-oriented knowledge management system for inquiring organizations

Hall [18] first developed, and later refined to include feedback loops [20,21], a conceptual model of a knowledge management system (KMS) based on the philosophies underlying inquiring systems. This work builds on the revised model. The result (Fig. 1) combines the flexibility of inquiring systems with an enhanced version of Simon's [44] Intelligence-Design-Choice (IDC) model to form a conceptual LOKMS for inquiring organizations. Loops that provide feedback and time/space analysis on the desired state/current state potential gap are evident throughout the system. The system contains modules and components that facilitate organizational decision-making and memory enhancement.

Systems based on this three-phase model contain 4 modules and 11 components that arise from the underlying philosophical bases of Churchman's inquirers ([8], see also Ref. [21]). Each of these plays a role in "guaranteeing" the integrity of the system. The modules will be discussed later in this paper in relation to the applicable decision-making process

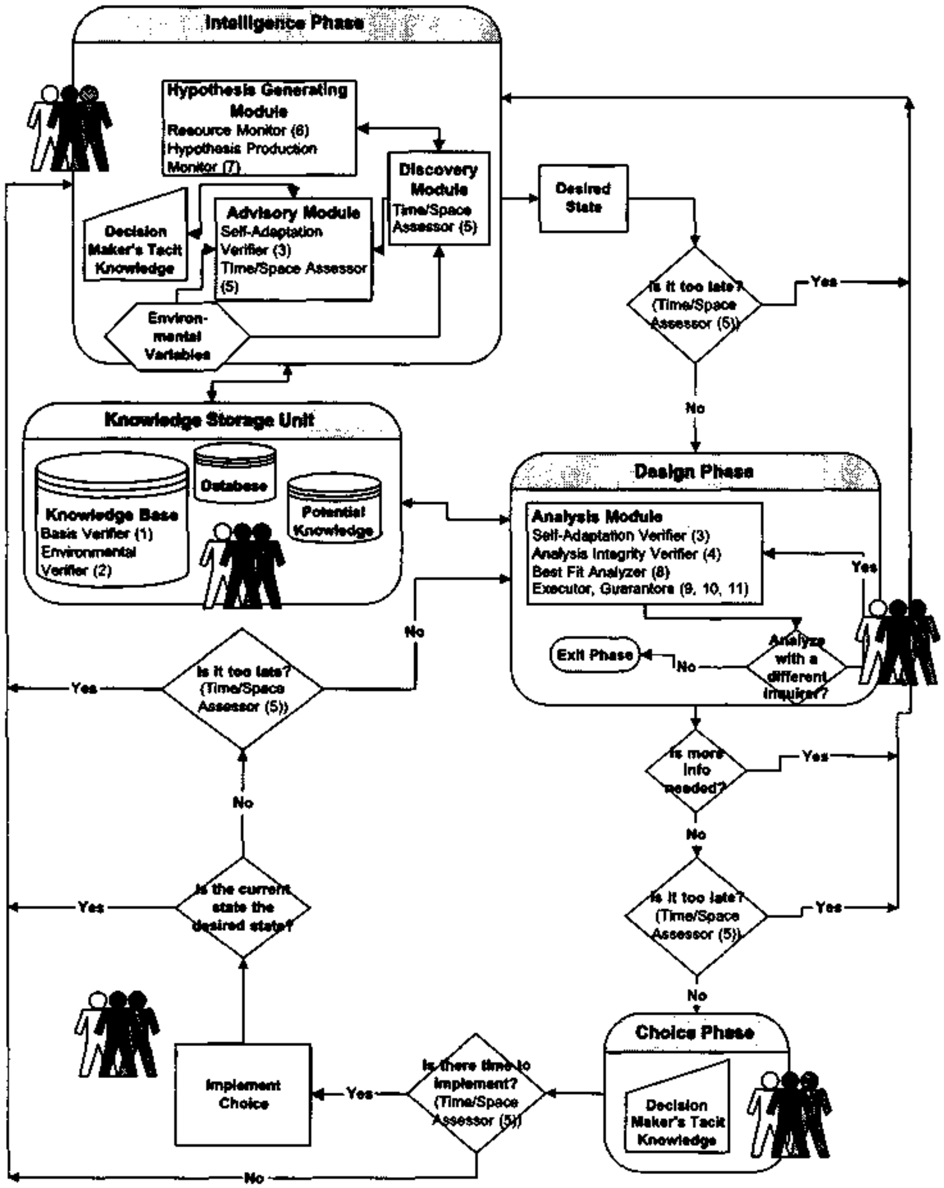

Fig. 1. Conceptual model of the learning-oriented knowledge management system (adapted from Ref. [21]).

steps; the components are briefly described in Table 1. One of the components is present throughout all aspects of the decision-making process, five components act exclusively in the design phase, and the remaining five components act in both the intelligence and design phases of the system. Because this design focuses on decision support for wicked problem environments, "choice" ultimately resides with the user. Consequently, the third phase of the system, Choice, does not have a technological component.

This model will be used to demonstrate the enhancements that the LOKMS provides during the decision-making process that, in turn, leads to organizational learning. The model is not designed to represent a fully automated system. It is highly dependent on the decision-maker(s), who in turn must

Table 1
Components of inquiring systems (adapted from Ref. [21])

	Component	Description of component's task	Phase
1	basis verifier	verifies accuracy of system basis	Intelligence, Design
2	environmental verifier	maintains currency as changes or additions occur to environmental variables	Intelligence, Design
3	self-adaptation verifier	monitors knowledge base changes to verify that new knowledge or relationships have not invalidated existing knowledge	Intelligence, Design
4	analysis integrity verifier	prevents assimilation of invalid knowledge store items	Design
5	time/space assessor	provides the ability to follow time-critical missions of the organization	System-wide
6	resource monitor	prevents resource exhaustion	Intelligence, Design
7	hypothesis production monitor	prevents overproduction of hypotheses	Intelligence, Design
8	best fit analyzer	ensures best data-to-model fit	Design
9	executor	provide for system integrity by performing checks of system performance	Design
10	best measures guarantor		
11	system guarantor		

be cognizant of the availability of the knowledge base and experiential knowledge available within the organization. The knowledge base itself is dependent on frequent communication between organizational members, during which some element of tacit knowledge is often articulated and becomes storable. While supporting the decision-maker(s) by providing some element of analysis, the system is not independent of human interaction. Individuals ultimately will determine the desired state, interpret environmental variables, make temporal considerations, select a solution, and determine checkpoints at which to check for progress toward the desired state. The individual will have benefited from the system's support and can react more effectively and quickly than otherwise might be possible. Ultimately, the learning-oriented knowledge management system for inquiring organizations is a system of individuals and advanced technology that might include transactional systems, decision support structures, expert systems, data warehousing, data mining, and collaborative software.

In addition to combining the disciplines of organizational learning and knowledge management, this model contributes to knowledge management system theory by virtue of its emphasis on information acquisition and discovery. The intelligence phase of Simon's [44] IDC model is often overlooked and yet it is an important (arguably critical) factor in information acquisition/discovery and problem definition. The LOKMS for inquiring organizations places much of its energy in the intelligence phase. Both proactive and reactive information acquisition occurs during this phase, as does problem definition. These activities form the basis of the first three steps in the decision-making processes outlined below.

6. The decision-making process within the LOKMS for inquiring organizations

The eight decision-making steps listed below are derived from the seven-stage systems approach to decision-making [33]. They have been slightly modified from the seven-stage approach to emphasize the feedback and proactive environmental scanning that are part of the LOKMS for inquiring organizations. Whereas the seven-stage systems approach begins when a problem is first apparent, the LOKMS approach begins with proactive information acquisition. Table 2 shows the modifications from the seven-stage model to the system's model and the organizational support components (both technological and human) that are most prominent at each stage.

There are many aspects of each major phase of the system that must be considered. How information is gathered and exchanged, how problems are structured, and the organizational support components necessary for each phase to be successful are some of the more important aspects of any organizational structure. However, they have particular importance in the inquiring organization because the support of these aspects allows the inquiring organization to respond flexibly and in a timely fashion to discovered opportunities or needs. The conceptual model is discussed below by the steps outlined in Table 2.

Table 2
Comparison of decision-process steps of the LOKMS for inquiring organizations to the seven-stage systems approach model

Seven-Stage Model Steps	LOKMS Decision-Process Steps	Components of Organizational Support	Explanation
(None)	proactive information acquisition (1)	communication, culture, leadership, intelligence phase	scan for opportunities or needs
Problem identification (1)	problem definition (2)	centralized knowledge store, communication, culture, intelligence phase	define opportunities or needs
Model building and data collection (2)	reactive information acquisition (3) review of existing knowledge and experience (4) definition of desired state (5)	communication, culture, leadership centralized knowledge store, intelligence phase, design phase	gather information based on defined opportunity or need; establish a desired state to be attained based on the problem definition and acquired information
Alternative generation (3) alternative evaluation (4)	action determination (6)	communication, culture, centralized knowledge store, intelligence phase, design phase	determine courses of action needed to achieve the desired state
Decision (5)	selection of action (7)	communication, culture, leadership, centralized knowledge store, intelligence phase, design phase	select the best course of action from those determined above
Implementation (6) monitoring (7)	implementation/monitoring /adjustment (8)	communication, culture, leadership, system-wide components	implement action choice, monitor progress, adjust action as necessary

6a. Step 1 (and step 3)—proactive (and reactive) information acquisition

Environmental analysis or scanning and information acquisition are often the first steps in organization adaptation [22]. Emerging information systems technologies, especially in the communications arena, enable information to be acquired more quickly, more cheaply, and in greater depth than ever before. Organizations must use those systems effectively to gather information relevant to the organization's goals. Environmental scanning can be effective for discovery and information acquisition if the organization creates an "environment of discovery" [16]. Inquiring organizations facilitate the process by having a proactive acquisition strategy, recognizing that action may need to be taken on newly found information, and making use of all available information channels.

The LOKMS for inquiring organizations facilitates information acquisition explicitly by providing for input from the individual in need of information, considering environmental variables (both internal and external) that may impact the organization's direction, providing time/space analysis to ensure timely action, and by centralizing the store of organizational knowledge as a knowledge base, an organizational database, and a store of potentially valuable information that has not yet been identified as new knowledge (the potential knowledge store). Communication between organizational members and partners is implicitly encouraged and generally required to acquire information, especially reactively.

The advisory module is one of three modules that are active in the Intelligence phase of the model, and it is supported by two components of the LOKMS—the environmental verifier and the time/space assessor. The environmental verifier continuously scans the knowledge base for accuracy in light of changed or new environmental variables and moves items that are no longer accurate in the current environment to the potential knowledge store. Within the advisory module, the time/space assessor helps the decision-maker determine whether a developed model has temporal feasibility and verifies that the knowledge store does not contain outdated material. Any outdated information is either removed permanently from the information base or moved to the potential knowledge store if its characteristics are such that the item may be used again.

6b. Step 2—problem definition

Accurate problem identification is critical in ensuring that reactive information acquisition returns relevant information. Additionally, accurate problem identification and the resulting formulation will determine the inquirer invoked during the design phase and, therefore, the guarantor that will oversee the analysis process.

The discovery module, located in the Intelligence phase of the model, combines new and existing knowledge in the system to generate new hypotheses for the decision-maker to consider as new knowledge is stored and existing environmental variables change or new ones are recognized. This updating of existing models in the face of new knowledge increases opportunity for organizational learning; this update process is often unavailable with traditional support structures. The time/space assessor supports the discovery module by producing hypotheses that are based on time-sensitive information that are approaching, but have not yet reached, a critical state.

Hypothesis generation is an important aspect of knowledge discovery software. The hypothesis-generating module, located in the Intelligence phase of the LOKMS model, facilitates this activity. Hypothesis-generating techniques must be able to initially assess patterns and relationships and build appropriate hypotheses. According to Balachandran et al. [2], the ideal tool for hypothesis generation would:

- support users in hypothesizing relationships,
- evaluate user-generated hypotheses,
- provide visualizations,
- support automated exploration of the hypothesis space (but allowing for interaction), and
- be effective in large knowledge stores with multiple dimensions.

While the discovery module of the LOKMS for inquiring organizations handles the first three characteristics, the hypothesis-generating module of the system handles the fourth and fifth ones. The hypothesis-generating module works with the discovery module and is derived from two of the underlying inquiring systems—the Leibnizian system and the Singerian system. Both of those inquirers have continuous scanning mechanisms that draw information from the potential knowledge store (Leibnizian) or the knowledge base or database (Singerian) and attempt to challenge and refine that information to create new knowledge. Because the hypothesis-generating module performs on a continuous basis, there is a risk of overuse of system resources. The hypothesis-generating module requires a resource monitor and a hypothesis production monitor. The resource monitor ensures that valuable system resources are not excessively consumed by this module; the hypothesis production monitor watches the incremental value of developed knowledge and prevents the generation of hypotheses that are too closely related to existing knowledge to be of value.

Although similar to the discovery module, the hypothesis-generating module does not update models and is not concerned with changes in the environment. It assists by applying new hypotheses to the discovery module's models to provide further information to the decision-makers and to help structure the problem before it is passed to the design phase. This step allows the design phase to designate more accurately which inquirer will perform the analysis.

6c. Step 3—reactive information acquisition

Steps 1 and 3 were discussed together above because they are both centered in the intelligence phase. The timing of the steps (whether preceding or following problem definition) is the only difference between the two. See Step 1 above.

6d. Step 4—review of existing knowledge and experience

Decision-maker(s) or acquisition stakeholder(s) must have the ability to scan the knowledge store for relevant knowledge, information, and expertise through the organization and, if applicable, throughout all organizational partners. The knowledge management system must enable this scan to happen quickly and efficiently, leaving valuable resources free for scanning externally as necessary. This is largely facilitated in this conceptual system by a central store of organizational knowledge.

The organizational knowledge store consists of the knowledge base, the organizational database, and a store of potentially relevant knowledge. The knowledge base is a concentration of facts, assumptions, and processes stored according to their applicable problem domains. This would generally be in the form of heuristics and individual contact and expertise information. The potential knowledge store is the store of potentially relevant information that has not yet been proven true or is not true in the current context. The organizational database is the store of data relevant to the organization's variables and transactions. Also in this store are the paths to tacit knowledge within the organization. These pathways are valuable in that they allow the information to be examined by individuals whose tacit knowledge enables them to identify more quickly opportunities or needs made evident by the new information.

6e. Step 5—definition of desired state

The advisory module, located in the intelligence phase, is capable of helping the decision-maker(s) define a desired state and begin to determine those steps necessary to achieve the desired goal. Drawing on the base of stored knowledge, the advisory module has the advantage of being able to access all relevant knowledge in the store and to draw appropriate assumptions. These assumptions provide the decision-maker(s) with additional information with which to make a determination of a desired state. Additionally, the component formulates models that inform the decision-maker(s) about processes that can be used to achieve the desired state. The desired state, problem formulation, and tentative process for achievement are passed to the analysis module of the design phase.

6f. Step 6—action determination

The design phase is the period during which the analysis module is active and actions necessary to reach the desired state are determined. The analysis module is the primary component of the design phase and is activated after conclusion of the intelligence phase (definition of the desired state). The analysis module is a combination of all five inquirers as described by Churchman [8].

The Leibnizian inquirer is appropriate for structured problems that have a definite solution and allow for analytical formulation. Its guarantor is its consistency. The Lockean inquirer is appropriate for structured problems that lend themselves to consensus, which is also its guarantor. The Kantian inquirer is most appropriate for problems that are moderately unstructured and frequently described by multiple perspectives, but which allow for analytical formulation. It has as its guarantor the "best fit" between the data and the model. The Hegelian inquirer provides support for problems that are divisive in nature and can be ill structured. The guarantor in the Hegelian inquirer is twofold—first in its conflict and second in a component called the over-observer that serves to synthesize the opposing views into one new view. The Singerian inquirer is capable of handling all problem structures and has as its guarantor replication and measurement. However, such a complex inquirer requires extensive resources and generally would not be invoked if a less complex inquirer was capable of analyzing the problem (for a more thorough discussion of the inquiring systems, the reader may refer to Refs. [8,11,21]).

The problem structure, as determined during the intelligence phase, will determine which of the inquirers is initially invoked. The guarantor of the selected system will then guide the process through the appropriate system path. If the result of the analysis is inconclusive, the module considers applying a different inquirer to the problem and initiates the appropriate guarantor. The successful outcome of this module is new knowledge or potential knowledge. A given problem may require many repetitions of the analysis module before all applicable new and/or potential knowledge is created. A decision-maker may then choose an appropriate course of action to move toward the desired state, based on the newly created knowledge. Not all knowledge generated will lead to a choice of action.

6g. Step 7—selection of action

Simon [43] believes there are three steps in the task of learning-oriented decision-making. They are listing alternative strategies, determining the consequences that follow the strategies, and the comparative evaluation of those consequences. The stages closely parallel his Intelligence-Design-Choice (IDC) model [44]. Whereas the IDC model emphasizes determining the problem, analyzing possible solutions, and choosing a course of action, the learning-oriented decision-making tasks emphasize understanding the consequences of the actions. Although the decision-maker has been active throughout the intelligence and design phases of the LOKMS for inquiring organizations, the automated features of the modules have allowed for alternative listing, consequence determination, and consequence analysis to have the benefit of being accomplished with organizational memory and knowledge rather than that of an individual decision-maker or decision-making group.

The LOKMS for inquiring organizations also addresses two other concerns that Simon [43] identifies during the learning-oriented decision-making process, those of time and knowledge. Time is a consideration because the choice of one strategy will reduce the strategies later available due to the investment of time spent on the first strategy. While choosing an alternate strategy later is possible, the possibilities are more limited. The time/space assessor mitigates this limitation in this system. Acquisition, sharing, and use of knowledge is, of course, the essence of the LOKMS for inquiring organizations and therefore addresses Simon's concern of enabling decision-maker(s) to form reasonable expectations of future consequences of a decision.

At the end of the design phase, the decision-makers will have been provided with new knowledge or potential knowledge based on the analysis of the desired state and associated variables. During the choice stage, the decision-makers are free to choose an action based on the newly created knowledge. Because of the nature of the guarantors in the design phase, the knowledge presented to the decision-maker is fully reliable if taken from the knowledge base. If the decision-maker uses the potential knowledge base in making the decision, he is more informed than before the analysis had occurred, because the knowledge therein has been thoroughly explored, even if it could not be proven at that point in time. If the variables analyzed during the design process were blatantly in error given what is currently known, that information would be stored with those variables in the potential knowledge base, and the decision-maker would have avoided using that knowledge in the decision.

6h. Step 8—implementation/monitoring/adjustment

The ability to monitor progress toward a goal and to modify actions dependent on that progress is instrumental both in goal achievement and as a learning opportunity. Once the action chosen has been implemented, it is imperative that the organization maintains vigil over progress toward the desired state. With the constant monitoring provided by the time/space assessor, the inquiring organization has the ability to either continue action, modify the action, or stop the action totally when (a) the desired state is reached, (b) the desired state is deemed unreachable, or (c) circumstances dictate the desired state should be changed. The interactivity of the system also allows an organizational member to make those checks as desired.

The ability to control the timing of the progress testing is very important. The timing of the testing and feedback must be such that it maximizes the efficiency of the process. Ill-timed tests are arguably as ineffective as no tests. Whether an organization is on the right or wrong path, if the feedback assessment is done at the optimum time, the subsequent choice of action is likely to be correct. If the feedback assessment is not done at the optimum time, the organization may choose to continue for the wrong reason, may choose to continue when it should not, or may choose to discontinue a beneficial action.

An important part of a feedback system's ability to properly time feedback loops is its ability to recognize both new potentially relevant knowledge or information and the temporal considerations of the organization. The self-adaptation verifier and the time/space assessor, in conjunction with the environmental verifier, ensure that this aspect of the feedback system functions properly.

The linear nature of text (in this paper and in the supporting tables) obscures the nature of the interaction between the user of the LOKMS and the LOKMS itself. On the surface, the interaction appears to be sequential and very process oriented, with little change occurring in either the user's perceptions of his/her environment or the LOKMS's "understanding" of the environment. In fact, the user and the components of the system work interactively and iteratively, continuously constructing a view of reality as more knowledge is accumulated about the environment.

A user's understanding of the environment sets the initial parameters that would guide proactive information acquisition (Step 1). In other words, a user's definition of the problem space (Step 2) and the desired state (Step 5) will guide the search of the problem space [45] (Steps 1 and 3). These definitions (Steps 2 and 5) will be built on the existing knowledge and experience of the user (Step 4). Deviations from such parameters represent problems [37] or opportunities, depending on the perspective of the decision-maker. Information acquired through the proactive information acquisition step (Step 1) may cause changes in the user's problem space definition (Step 2) and the desired state (Step 5), cause alterations to existing knowledge and experience (input to Step 4), and lead to reactive problem information acquisition (Step 3). (These changes also influence the next iteration of proactive information acquisition: Step 1.) The reactive information acquisition (Step 3) would likely investigate some new information areas and could lead back to additional adjustments in the problem definition (Step 2) and the desired state (Step 5). The information gained from this investigation could also lead to subsequent iterations of proactive information acquisition (Step 1). Action determination (Step 6) is driven by the problem definition (Step 2) and the inquirer invoked. Action selection (Step 7), as we have noted, is the user's choice. Once an action has been selected, the action implementation and monitoring (Step 8) brings the system back into information acquisition (Steps 1 and 3) phases of the decision-making process. Thus, one can see that these decision steps are constantly influencing the activities and outcomes of each other. Once environmental scanning has started, thinking in terms of a "sequence" in these steps may actually be misleading. In fact, the user and the system "learn" together the characteristics of the problem space and the operations that are effective within it.

7. An example

An example of a complex decision-making scenario in relation to the aforementioned steps can further explicate how this system design would be effective. In the example, extracted from Mitroff and Linstone [34], any references to the LOKMS or its procedures or components reflect where decision-maker/system interaction would have occurred if this example had been played out in an LOKMS environment.

Background: A pharmaceutical company has recognized a problem—a much lower priced generic drug of similar quality can replace its expensive drug (drug X). There is potential for severe financial impact from the generic drug. The culture of the organization is one of financial prowess—anything that may disturb the sound financial position of the company (the desired state) is a potential threat. A strategy to act on this information is required. Several decision-makers integral to the organization have been assembled to define the problem and determine an appropriate action to take.

Step 1 (proactive information acquisition) has occurred. Information has been gathered that, on the surface, indicates a potential problem. In the context of our LOKMS, this information was likely gathered by the discovery module and analyzed by the advisory module of the Intelligence phase. The advisory module would have issued a warning to the appropriate organizational member of a potential threat to the current state (financial stability). Organizational leadership has responded to the potential problem by assembling a group to define the problem and suggested a solution.

Step 2 (problem definition) appears straightforward. The bottom line of the company is potentially threatened; action should be taken to reinstate the company to financial stability despite the threat (the new desired state). During this step, hypotheses and models are generated by the hypothesis-generating module in coordination with stored knowledge and the discovery module to determine whether an obvious solution is at hand. Three solutions are surfaced by the assembled group: (1) increase the price of drug X, (2) decrease the price of drug X, or (3) maintain the price of drug X. The decision-makers split into groups according to their perspective of the incoming information and the potential solution. Each side had made specific assumptions and had interpreted information based on its own views, effectively editing out information that may have conflicted with the basic beliefs of the individuals involved. None of the groups was willing to accept the assumptions of the others because their perspective labeled that information as "false."

Step 3 (reactive information acquisition) and Step 4 (review of existing knowledge and experience) is engaged in by all three groups which utilize both organizational memory (stored knowledge) and the discovery module. Each group may also request hypotheses based on their findings. It is at this point that perspective and interpretation become prevalent. Rather than attempt to find information that adds to the understanding of the problem and potential solution, each group searches for information that supports only their understanding of the problem and solution, effectively narrowing their interpretation. When narrow perspectives such as these are acute, organizations may fail to reach the requisite variety necessary to interpret and react appropriately to environmental changes [49].

This narrowing cycle in this example was not broken until it became obvious in Step 5 (definition of desired state) that there was no meeting of the minds. The concept of stakeholder assumptions was approached with the organization (by Mitroff and a colleague, James Emshoff), and the decision-makers were encouraged to look at the problem through the perspective of the involved stakeholders. First, all stakeholders had to be identified, and the assumptions each stakeholder may hold were hypothesized. During this process, the analysis module of the design phase is active (for instance, assumptions are examined for accuracy against existing information, analyzed for best fit). This process is iterative and may include elements of stored knowledge as well as the discovery module, hypothesis-generating module, and advisory module. Eventually, all the decision-makers found they agreed on one critical certain item—that the patient desired high-quality drugs at the lowest possible price. They also agreed on one critical item of uncertainty—that physicians are price insensitive. The need to maximize profit or market share was an unknown that was not as clearly consensual throughout the group. The combination of leadership (consultants encouraging thinking "out of the box") and communication between the decision-makers, in combination with knowledge storage examination and the decision-maker's individual interpretations of information, eventually led to an understanding that the group did, in fact, have a common goal—to provide a high-quality drug to the patients and to position the price of drug X such that physicians would prescribe it and hopefully reject the generic drug. The outcome (the new desired state) would be one of financial stability.

Step 6 (action determination) required that the decision-makers conceive and select alternatives that would achieve the new desired state. The two alternatives chosen as viable were either to increase prices leading to profit maximization or to lower prices leading to market-share maximization. Because the group now had a common goal and a desired state that was supported by all decision-makers, members of the group more willing to listen to and consider accepting the views and assumptions of others in the group. Now that the group had a common goal, it also had formed the basis of a shared mental model—a necessary condition for effective decision-making [10]. This open and broadened communication led to the chosen alternative.

The alternative of increasing prices was selected in Step 7 (selection of action). This alternative was chosen because the effect of the higher price on the market could be seen, and it was believed the higher price would maximize profits, which would be more in line with the company's mission.

Although the case presented by Mitroff and Linstone [34] does not reveal the outcome, it is reasonable to suggest that after the selected action was implemented (Step 8), it was monitored to determine the effect the price increase had on profitability and market share. In the spirit of the LOKMS, this process would be iterative. If market share dropped but profitability had increased or remained constant, it would be assumed that the desired state and the current state were one in the same. If, on the other hand, market share decreased and profitability decreased, it would be assumed that the desired state and the current state were not the same, requiring that the process return to the design phase for further processing (perhaps the implementation of the second alternative).

One important note regarding this example is that the attainment of the desired state is the goal, and those steps, assumptions, and information necessary to achieve the goal become important pieces of information to be stored in the knowledge storage unit. However, should the desired state not be achieved, the steps, assumptions, and information that led to failure to achieve the goal are as important (and sometimes more so) than the same artifacts in a successful achievement of goal.

8. Discussion

Crossan et al. [12] suggest a framework for exploring strategic renewal within an organization. They suggest that most established organizations, particularly those engaged in renewal, contain knowledge created previously that should be exploited, but should be balanced with new knowledge creation/acquisition. To acknowledge that the organization is already learning places their framework within the capability perspective of organizational learning defined by DiBella and Nevis [14]. This perspective encourages organizations to focus on the processes by which learning occurs as well as what is actually being learned. Central to the arguments of both DiBella and Nevis [14] and Crossan et al. [12] is the concept of iteration within the system. Both feedback and feed-forward loops are integral infrastructure of effective organizational learning.

Crossan et al. [12] develop a theoretical foundation of four premises, which suggest that organizational learning for strategic renewal must (1) be concerned with new knowledge acquisition and creation, reuse of existing knowledge, (2) work on all levels within the organization, (3) have a social orientation, and (4) understand the interaction of cognition and action (which, according to the authors, separates organizational learning from knowledge management). Each of the premises outlined about can be found in the learning-oriented knowledge management system outlined in this paper.

The first premise, new knowledge acquisition and creation, is highly evident in the process of the system, in the intelligence-gathering module itself, and in the components of the inquirers inherent in the system. The centralized knowledge store (organizational memory), which contains not only currently relevant information and knowledge but also retains information that has potential to be relevant, is available to all organizational members to facilitate reuse of information and knowledge as appropriate, thus supporting the second and third premises. The learning-oriented knowledge management system is capable of working at the individual, group, or organizational level, also supporting the third premise. The social orientation premise is supported by the emphasis on an organizational member's expertise and experience and is inherent in the philosophical foundations of the Lockean, Kantian, and Singerian inquirers. The last premise, of an understanding of the interaction of cognition and action, is also supported by the foundations of the inquirers. Each inquirer requires a proactive approach to knowledge generation, particularly in its feedback routine that senses the gap between the effect of a given action and the desired state. The system conceptualized here uses that feedback to adjust models based on what is, or can be, learned from the outcome of a given action. The consequences of an action then become part of organizational memory.

In addition to the feedback loops inherent in the system, the learning-oriented knowledge management system also bridges the gap between organizational learning and knowledge management (as defined by Ref. [12]) by incorporating the importance of individual differences in perception and cognition and the impact those perspectives have on decision-making and learning. Courtney [10] describes the societal nature of the inquirers and suggests that the multiple-perspective approach supported by the inquirers may move organizations closer to understanding the technical, organizational, and personal perspectives espoused by Mitroff and Linstone [34] as being critical to organizational survival in tenuous times. The LOKMS specifically works toward building understanding of other perspectives among organizational members. Working within the confines of individual and organizational perspectives is an interpretation issue.

The perspective through which they are viewed affects interpretation of information and events. It can be difficult to overcome issues of interpretation, both at the individual and the organizational level. Interpretation of information is dependent on the underlying perspective from which information is viewed. Individuals interpret information from their unique perspective, making group consensus difficult and problem interpretation unnecessarily narrow. Organizational perspectives are based on the perspectives of their members and may even divide organizations into groups that hold differing perspectives [34]. Encouraging organizational members to understand the perspectives of others broadens the decisional context

[18], which in turn leads to an increase in decision quality within that context [28,44,47]. Further, the LOKMS encourages organizational members to challenge current beliefs and processes, which is likely to increase the understanding of a given problem or situation [48]. This process of encouraging understanding of the perspectives of others may increase decision quality by increasing the amount of information perceived as relevant [47] and may lead to increased group effectiveness. Russo and Schoemaker [42, p. 155] consider this process to be a facilitator of "healthy group conflict," which enhances the pool of alternatives from which the ultimate choice is drawn. These authors consider key elements of effective decision-making to be proper support for interpreting, gathering intelligence, agreeing on alternatives and the ultimate solution, and learning from the outcome and the process. Not only does the LOKMS support the first three elements, but it also provides support for feedback considered important by Russo and Schoemaker [42], Crossan et al. [12], and others.

The feedback loops embedded in the LOKMS provide the dynamic interaction that is evident in organizational learning but missing in knowledge management systems designed simply to store and retrieve documents or link experts with novices. Feedback is an important process that facilitates learning by allowing continuous update of both the knowledge stores and the mental models contained within the organization. Proper feedback is not only found at the end of a knowledge creating or problem solving cycle, but during the process as well. The intra-process feedback loops are evident in the LOKMS in its attention to temporal and contextual situations (is it too late to reach our objective, or is the objective already attained?).

Feedback is a necessary element in any organizational process, and timing of the testing and feedback loops is critical. This timing must be such that it maximizes the efficiency of the process. Ill-timed tests are arguably as ineffective as no tests. If the feedback assessment is done at the optimum time, the subsequent choice of action is likely to be correct. If the feedback assessment is not done at the optimum time, the organization may choose to continue for the wrong reason, may choose to continue when it should not, or may choose to discontinue an otherwise beneficial action.

An important part of a feedback system's ability to properly time feedback loops is its ability to recognize both new potentially relevant knowledge or information and the temporal considerations of the organization. The self-adaptation verifier and the time/space assessor, in conjunction with the environmental verifier, ensure that this aspect of the feedback system functions properly.

The learning-oriented knowledge management system also satisfies some of the top issues in knowledge management [30]. For instance, a concern of how to keep organizational knowledge current is addressed by the time/space assessor, environmental verifier, and the self-adaptation verifier. Verification of the relevance and legitimacy of the organizational knowledge base is addressed by the basis verifier, environmental verifier, and the self-adaptation verifier. Each of these issues is addressed by the best fit analyzer, the executor, and the guarantors.

Another item of concern listed by King et al. [30] is the need for attention to knowledge management system design. While interface and speed issues are foremost on the mind of an organization's managers, proper foundation and theory is important for system designers. Designers may use the conceptualized LOKMS as a high-level design from which to implement organization-specific knowledge management systems. Use of the LOKMS in this manner may serve to reduce a common knowledge management system implementation error—that of failure to understand the bond between information technology and organizational members.

Research shows that when technological implementation occurs in organizations, the chance of success is increased when the organization makes an effort to promote the positive aspects of the technology and provide training in advance of the implementation, and when leaders continue to foster positive images of the change during the initial implementation stages [38]. Knowledge management initiatives must be considered from a similar social perspective; that perspective is the essence of the inquiring organization.

One way to enhance adoption of a system is to implement procedures recommended for any major change. Indeed, change management is crucial. Many studies have been performed to study the phenomena of change, primarily because successful change is less likely than unsuccessful change. For instance, a study prepared by Hammer and Champy [23] indicated that close to 66% of major change projects fail to reach their objective. Barriers to success include resistance to change, limitations of existing systems, lack of executive consensus, and lack of a senior level "champion." One of the ways to help initiate change is to utilize one of many strategies designed to avoid common pitfalls. Such strategies are outlined by Bolman and Deal [4] and include training to develop new skills, participation and involvement, communication, and creating transition rituals. Jones and Pollard [27] list potential pitfalls that often become evident during change initiatives. The list is extensive; some of the items listed include cultural clashes, desertions, divided loyalties, preoccupation with the past, "second spouse" syndrome, and politicization.

New organizational structures and knowledge management systems are necessary to maintain competitive advantage and success in the current tenuous business environment. These structures must be able to implement an interpretive perspective that not only supports traditional decision-making, but also supports organizational culture and environmental issues as well. These structures must foster an environment in which these processes can evolve. Such a structure is an inquiring organization based on the conceptual model of a learning-oriented knowledge management system for inquiring organizations.

Both the conceptual model outlined here and the inquiring organization that employs it are complex; developing, testing, and implementing may be difficult. It will undoubtedly be based on individual factors of infrastructure and existing technology within an organization and should be designed, developed, and tested first for specific functions and then integrated into the overall system. For instance, extant data-mining software can be used for automated discovery and retrieval. Bots are another type of technology that can be used for discovery and retrieval (Webbots, chatterbots). Both of these can work in conjunction with an enterprise database management system (for instance, Oracle) to allow for dynamic organizational memory. As these technologies discover new information, that information would be reviewed by other technology (perhaps intelligent agents) for its timeliness, appropriateness, correctness, etc. (the role of the verifiers in the system).

It is our hope that researchers will use this model as a foundation for system design and testing; we have chosen to work within the boundaries of design theory on this paper, leaving specific implementation possibilities as a potential topic for future work. The range of implementation possibilities is boundless, especially in today's rapidly changing technology environment.

9. Conclusion

This paper has conceptualized a learning-oriented knowledge management system for inquiring organizations. It has noted where the flexibility inherent in an inquiring system is particularly useful for information acquisition, knowledge sharing, and organizational learning, which are critical to maintaining competitive advantage in the new, knowledge-based economy. The role of the learning-oriented knowledge management system for inquiring organizations, and its role in the decision-making and learning processes of an inquiring organization, has been discussed.

The knowledge management system conceptualized in this paper contributes to efficient decision-making and effective use of knowledge and knowledge creation. These processes are critical to an organization in today's turbulent environment. It is not enough, however, to prepare and implement such a system. Interaction between the system and the users must be carefully orchestrated from the beginning. After all, Mumby [35] states that organizations are "intersubjective structures of meaning that are produced, reproduced, and transformed through the ongoing communicative activities of its members," a very humanistic definition. An effective, accepted knowledge management system can empower individuals or groups to make decisions with increased knowledge, can help organizations manage diversity through an increase in organizational common knowledge, and can support a wide array of knowledge creating behaviors. An organization that adopts such a system will undoubtedly experience benefits.

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