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Abstract

For many years, organizations have been faced with increasing amounts of information but have not been able to adequately use that information in a way that allows for organizational growth. The ability of an organization to learn is likely to be the only competitive advantage left in an economy where technology can be a significant leveling factor. Integrating decision support systems and inquiring systems will produce support for a learning organization that is capable of complex problem formulation and solution. There are many similarities between inquiring systems and decision support systems. This paper suggests that decision support will be enhanced by integrating the theory of decision support in a comprehensive inquiring system that is capable of adapting to changes in the business environment. Development of such a system will ensure that decision-makers and managers can focus on the task of guiding an organization to its ultimate success rather than expending energy sorting through information to make accurate and timely decisions.

Introduction

The environment in which organizations conduct business is undergoing drastic changes, and will continue to do so in the coming years. The proliferation of information technology, especially networks and telecommunications, is eliminating physical and geographical barriers and allowing organizations to conduct business in ways never before thought possible. New industries are developing because of improved information technology and the resultant new economy. Along with these environmental changes comes the necessity to make decisions quickly, confidently, and effectively.

Decision support systems (DSS) are designed to complement a decision-maker's ability and expertise by providing information in an efficient manner. DSS must be able to organize, store, retrieve, and use data and information in a manner that allows decision-makers to perform effectively and in a timely manner.

The DSS concept is well-developed. Gorry and Scott Morton (1971), using the work of Anthony (1965) on managerial tasks and Simon (1960) on types of decision, suggested that an effective DSS should combine Simon's decision continuum with Anthony's managerial tasks to support decision making. Gorry and Scott Morton also moved away from traditional programming-based problem definitions toward more general terms emphasizing problem structure (Courtney 1999).

In organizational settings, *individual* or *small group* decision-making activities can impact *organizational* outcomes. When individuals or groups make decisions without benefit of full consideration of organizational parameters, the decisions made may be sub-optimal from the organizational perspective. Thus, organizations need information technology support structures with many of the same characteristics of DSS. These support structures must be both efficient and flexible, and must provide the organization with timely, accurate information on which to base decisions. These support systems must enable decision-makers to rely on information as *knowledge* when needed. However, organizational systems must also allow the organization to learn. Inquiring systems provide such an environment.

This research begins the task of conceptualizing the integration of decision support systems into inquiring systems in the context of five philosophical approaches described by Churchman (1971). The paper discusses knowledge-oriented characteristics of inquiring systems and describes the integration of DSS and inquiring systems.

Characteristics of Inquiring Systems

Decision-makers in today's organizations must react quickly to changing environments, and must be able to predict with some amount of accuracy the outcome of a course of action. This necessitates a DSS that is capable not only of physically managing data, but also of adapting existing knowledge within the organization to the changing environment. This type of system is an inquiring system.

An inquiring system is a system that has the ability to gather evidence, model that evidence in a way that represents that system's reality, and present the outcome as knowledge. Churchman (1971, see also Mason and

Mitroff, 1973; and Courtney, Croasdell and Paradice, 1998) describes five archetypal inquiring systems; each of these systems has a philosophical basis. Named after Western philosophers, the systems are, in order of relative complexity, Leibnizian, Lockean, Kantian, Hegelian, and Singerian. These systems each contain the concept of a guarantor; a component of the system that guarantees that the knowledge created by the system is not false. Because the outcome of these systems is knowledge, organizations that use such systems are learning, or inquiring, organizations (Courtney, et al. 1998).

One approach to developing an inquiring system is through a thorough understanding of Churchman's models. Understanding how each philosophical basis approaches knowledge creation, problem structure, and knowledge management is required. Structured control over these features, which is provided using inquiring systems, is the key to efficient DSS integration.

The Role of Knowledge in Inquiring Systems

Churchman (1971) believes that knowledge has various definitions according to the context of its use, and that the definition of knowledge is ultimately a very subjective perception to each individual. For instance, in a non-complex human-less system, knowledge can simply be a collection of information. However, when humans are involved, knowledge takes on a role of enabling an activity, or of creating a potential to act. For the purpose of this paper, however, the authors define knowledge as providing the cognitive ability, or the cognitive potential, to act when confronted with information.

Key categories of knowledge under this definition are tacit, explicit, deep, and shallow knowledge. Tacit knowledge is knowledge that is contained within an individual that is difficult to articulate, and explicit knowledge is communicable knowledge. Explicit knowledge is further categorized into procedural and declarative. Procedural knowledge is knowledge that defines how to complete a task, while declarative knowledge is informative. For purposes of this paper, deep knowledge is defined to be knowledge used by experts, and shallow knowledge is defined to be knowledge used by novices. Experts are able to draw on their tacit knowledge of "first principles" in problem domains, while novices require guidance.

Deep versus shallow knowledge is not to be confused with deep versus shallow problem domains (Courtney, Paradice and Ata Mohammed, 1987). A deep problem domain is often characterized by well-formulated, relatively static underlying principles. Shallow problem domains draw on a broad range of fundamental laws. In this paper, we are distinguishing how decision-makers of various expertise navigate in these environments, not the environments themselves.

All knowledge types except tacit and deep can be captured and stored in an inquiring system with little problem. Tacit or deep knowledge can be supported in an inquiring system by providing an individual with the means to articulate the knowledge. Once articulation has taken place, the knowledge has become explicit and can be stored.

Because the strength of an organization often lies within the tacit knowledge of its employees, the conversion of tacit knowledge to articulated or explicit knowledge is critical to the success of the inquiring system. Nonaka and Takeuchi (1995) describe the process of converting tacit knowledge to explicit knowledge as being an interactive, spiral procedure (see Figure 1). The interaction of tacit and explicit knowledge leads to knowledge creation, and is influenced by the modes and triggers inherent in the knowledge-building process. Socialization, externalization, combination, and internalization of knowledge are the modes by which tacit knowledge can be converted into organizational knowledge. The triggers are field building, dialog, linking explicit knowledge, and learning by doing.

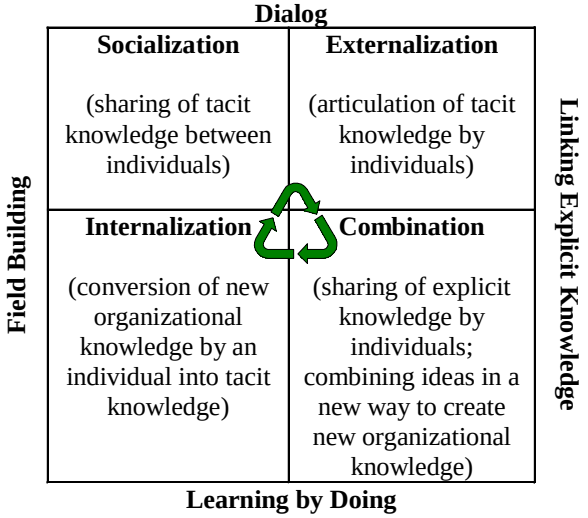

Figure 1. Knowledge Spiral

The Roles of Knowledge Management and Problem Structure in Inquiring Systems

Information technology both facilitates and exacerbates the need for organizations to manage growing information and knowledge bases. Improved technology allows organizations to accumulate more information and organize that information more efficiently. Some individuals see knowledge management as a technology issue and others as a management issue (Bock 1998). A

complete definition of knowledge management must include both the notions that knowledge is an asset and that knowledge management is a continuous process of creating, capturing, organizing, and using that asset. It includes establishing an environment in which knowledge can evolve (Davenport and Prusak 1998), which is the type of environment provided by inquiring systems, which in turn enables decision-makers to make viable, timely decisions, regardless of problem type.

Problems can be placed into one of three categories – structured, moderately unstructured, or unstructured (wicked) (Mason and Mitroff 1973). A structured problem is one that is easy to define, is repetitive and contains both known variables and known relationships. These problems have a high degree of objectivity and often resolve into a single solution that is provable. An unstructured problem is one that contains a high percentage of unknown or uncertain variables and relationships. These problems are difficult to define, and are highly subjective. Solutions to these problems often require that the decision-maker make "judgments of fact about the 'state of the system' both internally and in its external relations" (Mason and Mitroff 1973) and because of their subjective nature, their solutions are not definitively provable. Moderately unstructured problems have elements of both extremes. Because each problem definition can be assessed by at least one of the five inquirers, inquiring systems provide support under all problem definitions by selecting the appropriate form of inquirer capable of working with a specific problem definition.

Inquiring systems easily encompass the three paradigms of knowledge management discussed by Schultze (1998), using the Burrell and Morgan framework as a basis. The perspectives discussed by Schultze are functional, interpretive, and critical. The functional perspective supports the idea that organizations use knowledge management to achieve organizational objectives. The knowledge types commonly associated with this perspective are explicit and shallow. The interpretive perspective applies a social theory to information, stressing communication and interpretation in the system. The knowledge types commonly associated with this perspective are explicit and shallow. The critical perspective examines the organization for conflict. The critical perspective can contain explicit and deep knowledge. However, because of its different worldview orientation, this perspective can also provide support for tacit and deep knowledge.

Very often, knowledge management is the memorization of successful, verifiable results from previous ventures (Malhotra 1997). This process works for structured problem definitions, where the decision-maker can scan the knowledge base for a similar situation and choose the approach that worked previously. Additionally, many knowledge management systems support transferring knowledge, but to be truly efficient, the system must support integrating knowledge (Grant 1996). Grant states that management should encourage workers to challenge assumptions and "truths" in the workplace to allow the organization to evolve its knowledge base. When what is known is continuously challenged, the organization is exhibiting characteristics of the system that Churchman (1971) describes as a Singerian inquirer.

Five Philosophical Approaches to Inquiring Systems

The mere acquisition of knowledge is not enough to sustain an organization in today's dynamic environment. The system must present and manipulate the knowledge in such a way that the organization is capable of acting on that knowledge in a timely fashion. Each of Churchman's five systems performs its functions clearly and decisively. An organization may find that one, or all, of the inquiring systems described by Churchman are appropriate in establishing a learning orientation. An overview of Churchman's inquiring systems is presented in Table 1.

Table 1. Churchman's Five Inquiring Systems

	Guarantor	**Knowledge Management Perspective and Primary Managed or Supported Knowledge Types**	**Problem Type**
Leibnizian	Consistency	Functional perspective, explicit, shallow knowledge types	Structured (has a solution, allows for analytical formulation (symbolic representation))
Lockean	Consensus	Functional and interpretive perspectives, Explicit and shallow knowledge types	Structured, has a strong consensual position
Kantian	Fit between data and model	Functional perspective, explicit, tacit, deep, and shallow knowledge types	Moderately unstructured, may not have clear solution, allows for analytical formulation
Hegelian	Conflict, over-observer	Critical perspective, explicit, tacit, deep, and shallow knowledge types	Unstructured, divisive
Singerian	Replication	Functional, interpretive, and critical perspectives, explicit, tacit, deep, and shallow knowledge types	Structured, moderately unstructured, unstructured

Each of the three knowledge management perspectives can be assigned to the five philosophical bases by their inquiry type. The functional perspective is deductive, as are both the Leibnizian and Kantian systems. The Lockean system typifies the inductive, communicative nature of the interpretive perspective, but includes components of the functional perspective as well. The conflictual nature of the Hegelian system matches the

conflictual critical perspective. The Singerian system, because of its flexibility, can encompass all three perspectives.

Each of the five bases can support all knowledge types; however, each system has specific types that it manages more naturally. Those perspectives that view knowledge primarily as an object (functional and critical) will primarily manage objective knowledge types such as explicit and shallow knowledge. Those perspectives that view knowledge primarily as a process (interpretive and critical) will manage objective knowledge types and provide support for subjective knowledge types such as tacit and deep knowledge.

These systems are complex structures that support knowledge creation and management, but also support decision-making. There are many similarities between inquiring systems and decision support systems.

Similarities between Decision Support Systems and Inquiring Systems

Churchman (1971) and Gorry and Scott Morton (1971) began work on their respective systems at the same time. Both Gorry and Scott Morton's DSS concept and Churchman's inquiring systems involve the use of computer-based support for problems generally categorized as semi-structured or unstructured, and provide for structured problems to be solved primarily at the machine level. Since the introduction of both concepts, there have been developments in DSS research that demonstrate similarities between DSS and inquiring systems and suggest that they can be successfully integrated.

Both Churchman (1971) and Keen and Scott Morton (1978) emphasize that while structured problems can often be handled by machines, an inquiring system or DSS is not intended to replace the decision-maker. Rather, it enhances the decision-maker's efficiency. Additionally, Keen and Scott Morton (1978) describe four levels of support that can be provided by a decision support system: information retrieving, filtering, computing/comparing, and modeling. All of these are supported by inquiring systems.

Bonczek, Holsapple and Whinston (1981, see also Holsapple and Whinston, 1996) discuss the importance of modeling in support systems. The authors note that integration between modeling and data handling is important when designing a DSS. They discuss the importance of specialized DSS in organizational units, and examine the trend within organizations toward integrated systems that can handle a wider range of problems. Such integration is the nature of Churchman's (1971) inquiring organizations.

Chuang and Yadav (1998) discuss adaptive decision support systems (ADSS). Using Holsapple et al.'s (1993) definition of adaptive as being self-teaching, the authors further define ADSS as a type of DSS that can adapt itself to its users' needs. An important feature of ADSS discussed in this paper is the ability of the system to adapt to its changing environment and to new information. The potential to accomplish these changes is also present in Churchman's (1971) inquiring systems. Chuang and Yadav (1998) also list five functions that an ADSS should be able to handle, which are multiple scenarios, multiple views, multiple modes, multiple problem situations, and automated learning for presentation. In another paper (Hall and Paradice 2000), we describe inquiring systems components that can handle those functions as necessary, and can handle simplistic scenarios.

In their paper on the use of critique and argumentation in DSS, Vahidov and Elrod (1999) identify several elements (see the "Elements of an Effective DSS" column of Table 2) that should be included in an effective DSS. Several of the desired elements are inherent in inquiring systems. The inquiring system or systems that best support each element are listed in the "Inquiring System" column in Table 2.

Table 2. Compiled from Vahidov and Elrod (1999)

Page	Elements of an Effective DSS	Inquiring System
250	Handle agents with conflicting goals	Hegelian system
250	Should be proactive, should interact with environment	All five systems
251	Balance between divergent and convergent thought processes	Singerian system
251	Creative discontent to enhance quality decision-making	Hegelian, Singerian systems
253	Counter-arguments	Hegelian system

Combining inquiring organizations with Mitroff and Linstone's (Mitroff and Linstone 1993) Unbounded Systems Thinking, Courtney (1999) develops a new paradigm for decision support systems. In this paper, Courtney discusses how organizations that use Churchman's Singerian inquiring system go beyond the traditional concept of DSS support (analytical and inductive) by encompassing a worldview perspective and embracing the social aspect of problem solving and unbounded systems thinking.

Discussion

For many years, organizations have been faced with increasing amounts of information but have not been able to adequately use that information in a way that allows for organizational growth. DSS, among others, are often seen as the most effective way to store and manipulate information that is available to the organization. However, DSS often fail because they force problems into

a predefined problem structure that may be inappropriate for the problem at hand.

DSS have traditionally focused primarily on the "choice" phase of Simon's (1960) intelligence-design-choice decision-making model, with less emphasis on "design" and almost no attention to "intelligence." "Design" has often been a process of identifying variables that fit into a predefined model structure (e.g., a spreadsheet in the simplest case; an optimization model in more complex cases). Implicit in this situation is an assumption that the existing DSS model structure is appropriate and that the assumptions inherent in the model structure are applicable. Integration of DSS into inquiring systems concepts explicitly recognizes that multiple model perspectives may be needed, that problems may, in fact, be quite ill-structured, and that problem solutions may need to be constructed or synthesized from new combinations of existing knowledge with new information, rather than simply derived from existing data sets.

Inappropriate problem formulation leads to an inability to apply existing relevant organizational knowledge to the problem. Thus, decision-making effectiveness suffers and the organization fails to learn as efficiently as it could. These consequences may be critical in today's business environment. It is likely that the only way for an organization to maintain competitive advantage in the future will be to evolve into a learning organization that excels in its decision-making processes.

Integrating aspects of DSS and inquiring systems will produce a learning organization that is capable of more efficient and effective complex problem formulation and solution. By shifting some of the human decision-making process of problem formulation into the DSS arena, executives will have greater opportunities to focus more on the "intelligence" aspects of decision making, that is, problem identification and opportunity recognition. The guarantors inherent in the inquiring systems and their enhanced problem formulation and resolution capabilities will give executives greater confidence in the decision-making support provided.

An important part of such a system is gaining organizational acceptance. DSS are a known and accepted system in the business environment. Demonstrating the similarities between DSS and inquiring systems is the first step in allowing a complex support system to gain acceptance within the organizational community. Learning organizations equipped with a complex support structure designed using both DSS and inquiring systems will be better equipped to withstand the pressures inherent in a rapidly changing environment and as the new global economy moves from a production orientation to a service orientation.

Summary

This paper suggests that decision support will be enhanced by integrating the theory of decision support in a comprehensive inquiring system that is capable of adapting to changes in the business environment. The philosophical bases on which this system is built provide decision-makers with decision-making support under all problem definitions. The philosophical bases provide flexibility through the use of varied conceptualizations of knowledge, and validity through the use of comprehensive guarantors. Systems such as these can form the foundation upon which inquiring organizations can be built. An inquiring organization can utilize support systems designed in this manner to create, accumulate, and manage knowledge critical to its core competencies.

Development of such a system will ensure that decision-makers and managers can focus on the task of guiding an organization to its ultimate success rather than expending energy sorting through information to make accurate and timely decisions. This support system can offer expedient and accurate problem solving assistance in most organizational environments. Such a system is not only advisable, but should be required in an arena where change is inevitable and "time is money."

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