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Organizational knowledge resources

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Abstract

Decision-making episodes are knowledge intensive processes, operating on and adding to organizational knowledge resources. Decision support systems (DSS) perform some of the knowledge management (KM) that is integral to these episodes. Interest in the field of KM, among both practitioners and researchers has mushroomed in the late 1990s. Initiatives that aim to deliberately, explicitly manage organizations' knowledge resources have become commonplace. A basic prerequisite for fully understanding how an organization can, could, or should conduct KM is an appreciation of the kinds of knowledge resources it has. In this paper, a framework of knowledge resources is introduced, focusing on identifying and organizing basic classes of knowledge resources, and supplemented by the identification of attribute dimensions for characterizing knowledge across these classes. Developed via a Delphi methodology involving an international panel of practitioners and researchers, this framework is assessed as being relatively successful in terms of completeness, accuracy, clarity, and conciseness criteria. The result is a basis for investigating effects of alternative knowledge resource portfolios, and for studying how an organization does, could, or should conduct its KM — including its decision-making episodes.
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1. Introduction

Even in its formative decade, the decision support system (DSS) field was recognized as dealing with technologies for representing and processing knowledge in order to facilitate decision making [4]. A key DSS component is its knowledge system which holds representations of descriptive, procedural, and/or reasoning knowledge. Another key component is its problem processing system which can draw on the knowledge representations in the course of solving or recognizing problems that occur in a decision-making process. The net effect is that a DSS amplifies the decision-maker's capacity for handling knowledge: the raw materials, work-in-progress, by-products, and finished good of decision making. This amplification helps the decision-maker relax or overcome cognitive, temporal, and economic constraints; as such, DSSs may be instrumental in achieving a competitive advantage [22].

Technologies for decision support fall under the broad notion of knowledge management (KM) [13,21]. However, the KM field also encompasses

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many non-technological facets, issues, and methods. It is approached from such angles as cognitive science (e.g., psychology of the human mind), philosophy (e.g., the nature of human knowledge), law (e.g., intellectual property rights), ethics (e.g., knowledge privacy), accounting (e.g., measuring intangible assets), communication/sociology/education (e.g., knowledge transfer and creation), library science (e.g., knowledge codification and classification), organization science (e.g., fostering cultures and devising incentives that promote knowledge sharing and organizational learning), and strategy (e.g., devising KM initiatives and appreciating their competitive impacts).

The KM field is not concerned with knowledge representation and processing solely in the context of decision making. For instance, KM encompasses the knowledge handling that occurs in performing transactions, training, experimentation, and research. Nevertheless, decision making is a prime KM application. As Gordon Petrash says, "Knowledge management is getting the right knowledge to the right people at the right time so they can make the best decision" [12]. Within this KM umbrella, we could say that a DSS is computer-based technology that aims to get the right knowledge in the right form to the right persons at the right time so they can better make decisions and make better decisions.

Our focus here is on the possible kinds of "right knowledge." As decision-makers, we need to know what are the classes of organizational knowledge resources available as candidates for being the "right knowledge." Some of these resources may be delivered via DSSs, whereas others are not. We advance a relatively comprehensive framework characterizing organizational knowledge resources as a way of positioning DSSs within the KM world and to help guide resource considerations in planning and directing KM initiatives. To help develop this framework, we enlisted the assistance of an international panel of KM practitioners and academicians. Through a Delphi process, panelist critiques and suggestions were elicited to improve on an initial resource framework synthesized from multiple sources in the literature. The resultant characterization of organizational knowledge resources is presented here.

We begin with a brief background discussion of knowledge and its importance as an organizational resource. The collaborative Delphi approach to developing the organizational knowledge resource framework is then described, followed by a presentation of the framework itself. This includes a hierarchical classification of knowledge resources, plus an identification of attribute dimensions that can be applied to the resource classes. The panel's assessment of the presented framework is examined; it shows that a majority of panelists judge the framework's completeness, accuracy, clarity, and conciseness to be in the successful to extremely successful range. We conclude with a brief discussion of the framework's implications for research and practice in the KM and DSS fields.

2. Knowledge and its importance as an organizational resource

From a resource-based perspective, organizations are studied in terms of how their resources can predict their performances in a dynamic, competitive environment [6]. An organization's competitive advantage stems from the uniqueness of its resource mix and the inability of competitors to replicate that mix [28]. The value of a particular resource to a firm can be magnified by the presence of other resources and its interplay with them [6,43]. According to Amit and Schoemaker [2], resources are "stocks of available factors that are owned or controlled by the firm" and an organization's capabilities refer to its "capacity to deploy resources." Traditionally, the focus has been on stocks of monetary, human, and material factors.

From a knowledge-based perspective of organizations, the focus is on managing knowledge resources, and the associated aspects of human and material (i.e., computer) resources having capabilities for governing, operating on, and otherwise deploying knowledge [20,32]. The deployment of other organizational resources is seen as secondary, being driven by the combined effects of the organization's processors (human and computer) operating on its knowledge resources — as epitomized in an ongoing panorama of decisions being made. This is in accord with the contention of Penrose [33] that connections between an organization's tangible resources and the services they provide are mediated by managerial

knowledge, an intangible organizational resource subject to continuing growth. An organization can be viewed as an institution for integrating knowledge [11]. Heading in the direction of a knowledge-based theory of the firm, Spender [40] views an organization as a dynamic, knowledge-based activity system, maintaining that it is an organization's knowledge and ability to generate knowledge that form the core of such a theory. We suggest that beyond the ability of knowledge processors to generate knowledge, other activities that operate on knowledge resources are important to consider (e.g., acquisition, internalization, selection, externalization) [15]. Be that as it may, our focus here is on identifying the basic classes of knowledge resources that belong to an organization. These classes define the structure of an organization's portfolio of knowledge assets. An organization's specific assets in each resource category are used by its processors in the conduct of KM, leading to its competitive standing. Varying the specific knowledge assets within categories and allocations across categories affect organization performance, as do variations in the usage of these resources.

In the conduct of KM, organizational knowledge resources are operated on by human and/or computer processors in performing knowledge manipulation activities to create value for the organization in the form of learning and projections [15]. The conduct of KM is constrained and facilitated by a variety of influences factors [16], and it unfolds in an organization as a pattern of interrelated KM episodes (KMEs). As illustrated in Fig. 1, each KME is triggered by a knowledge need and culminates when that need is satisfied (or the episode is abandoned). A KME involves the execution of some configuration of knowledge manipulation activities by some assortment of processors operating on available knowledge resources to develop the needed knowledge.

The KME concept comes from the communications literature, referring to a pattern of activities performed by multiple processors with the objective of meeting some knowledge need [23]. Decision-making episodes are an important special case of KMEs. Triggered by a recognition of the need for a decision (i.e., for knowledge indicating a commitment to a particular alternative), the episode involves one or more decision-making participants (i.e., humans, and possibly DSSs) who carry out some knowledge manipulation activities, drawing on some portion of the knowledge-resource portfolio and culminating in new knowledge committing the organization to some course of action. Decision-making episodes can spawn problem-solving episodes, special cases of KMEs at a more micro level, where the knowledge needed is the solution to some problem of interest to the decision-maker. Yet another special case of the KME concept is the notion of a knowledge acquisition episode that is concerned with satisfying a knowledge need in the course of developing an artificially intelligent system [19].

What, then, are the major classes of organizational knowledge resources available for KMEs, that should be considered in devising and implementing an organization's KM initiatives, that should be considered in research about the nature of knowledge-based organizations? A comparative analysis of KM

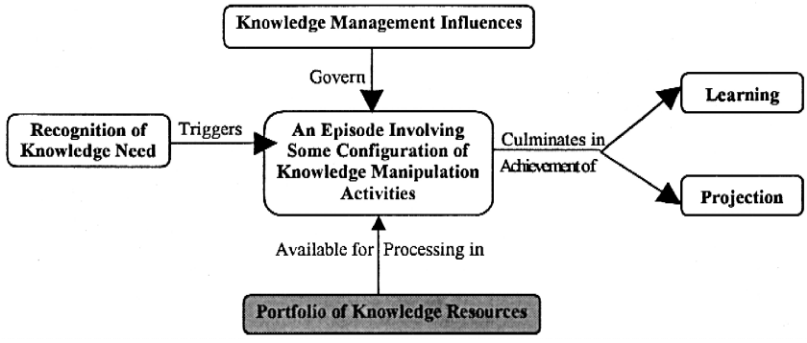

Fig. 1. Architecture of a KM episode.

frameworks reveals that the knowledge resource portfolio has received relatively little attention [14]. Three KM frameworks that explicitly identify different kinds of knowledge resources are summarized in Table 1. Leonard-Barton [24] identifies two types of organizational knowledge resources: employee knowledge and physical systems (e.g., machinery, databases). Interestingly, she also differentiates between an employee's knowledge and the skills an employee has (e.g., for manipulating knowledge). The Petrash [34] framework identifies additional knowledge resources. It recognizes employees' knowledge as human capital, but adds four additional kinds of knowledge resources: customers (referred to as customer capital), organizational processes, organizational structures, and organizational culture. The latter three are referred to as organizational capital. Sveiby's framework is similar [42]. However, it incorporates customer capital within the notion of external knowledge resources, which includes knowledge resources other than customers (e.g., suppliers). Most other frameworks posited in the literature assume that knowledge resources exist, in that knowledge manipulation activities must operate on something. However, they have little to say about resource differentiation. Some researchers concentrate on one or another attribute of knowledge such as modality of human knowledge resources (i.e., tacit vs. explicit) [30]. While the study of a knowledge-attribute dimension is interesting, it does not tell us about the portfolio of knowledge resources on which KMEs are built.

Which of the classification approaches summarized in Table 1 is preferable? Can the approaches be combined in some organized way? Are there classes of knowledge resources not covered in Table 1? In the quest for a relatively comprehensive, clear, accurate, and concise framework of organizational knowledge resources, a Delphi methodology is used. This is a collaborative exercise that can itself be seen as a KME, triggered by the recognition of a need for such a framework and culminating in the learning of a new perspective on organizational knowledge resources plus its projection embodied in this paper.

Table 1
Types of knowledge resources identified in KM frameworks

Author	Knowledge resources
Leonard-Barton, 1995 [24]	1. Employee knowledge 2. Knowledge embedded in physical systems
Petrash, 1996 [34]	1. Human capital 2. Organizational capital 3. Customer capital
Sveiby, 1997 [42]	1. External structures 2. Internal structures 3. Employee competencies

3. Methodology

A Delphi process [25] begins with an initial statement (e.g., of some prospective policy, position, or decision) being distributed to panelists to elicit their independent critiques and suggestions. These are used by the process coordinator as a basis for revising the statement to accommodate panelists' concerns and views. The revised statement is distributed to the panelists for another round of review/comment and possibly further statement revision. The process iterates in this fashion in an effort to reach consensus about approval of a revised version of the statement.

Here, we are concerned with the statement of a framework characterizing organizational knowledge resources. An initial framework, as reported by Holsapple and Joshi (in press), was synthesized on the basis of a review of the KM literature pertaining to organizational knowledge resources. The statement of this framework was distributed to panelists along with a structured questionnaire asking each for his/her views on the framework from the standpoints of completeness, clarity, accuracy, conciseness, and any other criteria of interest.

There were 122 candidate panelists, comprised of contributors to KM literature and conferences for whom addresses were readily available; 31 chose to serve as panelists (see Acknowledgement). Of these, 43% were researchers, 43% were practitioners, and the remainder were in both categories. Among practitioners, one-half had job titles involving CKO or CEO roles, while the others identified themselves as consultants. A majority of panelists indicated that North America is the region of their main work activity, although five continents were represented.

Panelists exhibited considerable variety in the perspectives from which they approach the KM field: 22% information systems, 13% management, 13% strategic management, 9% computer science, 9% public administration, with the remaining one-third coming from angles such as philosophy, sociology, communication, economics, finance, human resources, management science, and cognitive science. Over half the panelists indicated at least 5 years of involvement in the KM field, and all indicated KM contributions in the form of books, articles, reports, and/or conference presentations.

Collectively, the panelists have considerable depth of KM experience, exhibit a balance between research and practice, and represent the diverse assortment of backgrounds and perspectives that is a hallmark of the KM movement. Their responses to scaled and open-ended questions about the initial resource framework were stored in a database, which we used to help produce a document analyzing the responses. The document was organized into sections for each of the four main framework assessment criteria. Within each section, responses were separated into those to be considered in framework revision and those beyond the research boundaries (e.g., calls for a framework that makes prescriptions about knowledge resources). Responses of the first kind were partitioned into three groups: those that panelists repeated frequently or designated as major concerns, those that were less frequent/crucial, and those that were isolated, minor, or incidental. Based on ideas suggested by and stimulated by the panelist responses, the framework statement was modified in an effort to address the expressed concerns. The greatest effort was given to handling the first group of concerns (frequent/major) and the least was required for the third group. Some modifications were fundamental, some were additive, and some were clarifications.

The revised framework, the response analysis document, and the same type of questionnaire used in the first round were submitted to each of the panelists. In the 3-month window allocated to receive responses, 17 replied (41% researchers, 47% practitioners, 12% both). Second round responses were analyzed in the same way as those in the first round. In terms of both scaled and qualitative assessments, the resultant response and analysis document showed sufficient agreement with the revised framework that a further round was determined to be unnecessary (i.e., would result in little change). Following a presentation of the final framework in Section 4, panelists' qualitative and scaled assessments of it are described.

4. A framework of organizational knowledge resources

The framework recognizes four main kinds of organizational resources: financial, material, human, and knowledge resources. We focus on the latter. Knowledge manipulation activities (e.g., performed by human resources) operate on knowledge resources (KR) to create value for an organization. On one hand, the value generation depends on the availability and quality of the knowledge resources. On the other hand, productive use of knowledge resources depends on the application of knowledge manipulation skills (e.g., exercising a kind of human resource or a DSS) to execute knowledge manipulation activities. The framework involves a taxonomy for classifying an organization's knowledge resources, plus a summary identification of attributes that can be used in characterizing such resources.

4.1. Knowledge resource taxonomy

The taxonomy stems from a simple observation about an organization's knowledge resources: some can exist independent of the organization to which they happen to belong, while others depend on the organization for their existence. We refer to the latter as schematic resources and the former as content resources. The schema knowledge resources shape the working of an organization. Collectively, they establish an organization's ongoing identity. They are the basis for attracting, organizing, and deploying content resources. The content knowledge resources that exist at a given time qualify, condition, and color an organization's identity. They populate, instantiate, and enrich the frame of reference furnished by schematic resources.

As illustrated in Fig. 2, the framework's taxonomy identifies four schematic resources — **culture**,

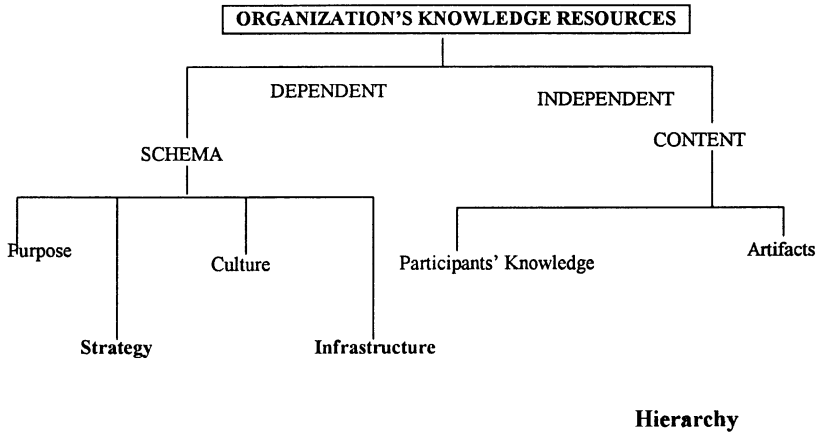

Fig. 2. The framework's knowledge resource hierarchy.

infrastructure, **purpose**, and **strategy**. Each is a source of revenue or wealth for an organization. Each denotes an organizational knowledge resource whose existence depends on the organization's existence. Each may change over time, but is invariably present as a knowledge resource. This taxonomy of schematic knowledge resources is consistent with traditionally studied topics in the management literature, although they are not typically viewed as being knowledge resources. This consistency provides KM researchers a base on which to build. Practitioners' familiarity with these topics should enhance the usability of this classification in managing the conduct of KM.

Content resources are comprised of **participants** and **artifacts**. A participant's (e.g., employee's) knowledge or the knowledge represented in an artifact (e.g., policy manual) can have an existence apart from the organization that happens to host it at any given time. Each is not only subject to change over time, but is also subject to elimination. The existence and use of content resources in the conduct of KM is both enabled and constrained by the schematic knowledge resources.

Both schema and content are essential portions of an organization's knowledge resources. If schema resources are eliminated from the KR classification, then would artifacts and participants' knowledge be sufficient to define an organization's knowledge resources? We suggest not. Participants and artifacts may come and go, but an organization's knowledge resources have a more enduring aspect that gives the organization continuity in the face of these comings and goings. Beyond the scope of participants and artifacts, knowledge is ingrained in an organization itself by way of its infrastructure, culture, strategy, and purpose. Schematic knowledge resources depend on the existence of the organization rather than on the existence of any particular participants and/or artifacts. However, representations of each can be embedded in artifacts and/or participants' knowledge.

The six types of knowledge resources identified in Fig. 2 are both distinct and interrelated. For instance, strategy is distinct from purpose (i.e., alternative strategies are possible for a given purpose), yet strategy should conform to purpose; culture is distinct from infrastructure yet culture can constrain infrastructure and vice versa; each schematic resource is distinct from content resources, yet it may be represented in a participant's knowledge or as an artifact.

Aside from knowledge resources identified above, an organization has access to knowledge existing in its environment via its knowledge acquisition activity. The environment's knowledge resources are a crucial source for replenishing and augmenting an organization's knowledge resources.

4.1.1. Content knowledge resources

Content knowledge is embodied in usable representations [29]. The primary distinction between par-

ticipants' knowledge and artifacts lies in the presence or absence of knowledge processing abilities. Participants have knowledge manipulation skills that allow them to process their own repositories of knowledge; artifacts have no such skills. A participant's knowledge is made available to an organization by means of that participant's knowledge manipulation skills. In contrast, an artifact is not accompanied by a processor and does not depend on a participant for its existence.

4.1.1.1. Participants' knowledge. An organization's participants include employees [24,41,42], customers [41,42], suppliers, partners, consultants, and computer systems [24,42,46]. An organization's participant knowledge resource is affected by arrival and departure of participants, participant learning, the portion of each participant's knowledge that is brought to bear on organizational work, and interrelationships allowed by schematic knowledge. One way to classify such participants is based on differences in composition. A participant can be an individual, an organization of individuals, a computer system with knowledge manipulation skills (e.g., a DSS or a combined computer and human system). Thus, participants can be human resources and/or material resources, but the knowledge possessed by each is a knowledge resource. Participants can also be classified as core participants or those that are ancillary to an organization. Core and ancillary examples for each composition class are exhibited in Table 2.

Even though the ancillary participants do not belong to an organization's collection of human and material resources, some portion of their knowledge may be regarded as virtual knowledge resources employed for the purposes of learning and projection. This is consistent with the network organization view, with core participants' knowledge being a resource of the network's core firm, ancillary participants' knowledge being resources of the network organization's partner firms and both being a resource of the network organization [5,10].

Human participant knowledge is knowledge that a person or a collection of persons (e.g., group, team, or other social entity) is willing to manipulate or make available in the execution of the organization's knowledge manipulation activities. The extent to which such participants make their knowledge available as an organizational resource depends heavily on managerial influences (e.g., leadership, reward systems, evaluation systems) [16], as well as alignment with schematic knowledge resources such as culture and purpose.

Computer-based participant knowledge is knowledge stored in a computer system that can perform one or more of the knowledge manipulation activities. This includes decision support systems, performance support systems, and expert systems. For example, General Electric's answer center has collected customers' complaints in a database. This knowledge is part of a system that aids operators in handling customer complaints and concerns for 1.5 million potential problems [42]. A computer system can preserve, formalize, and consolidate knowledge from various sources [7].

Hybrid participants' knowledge is knowledge made available or used by joint human–computer entities. An example of a hybrid participant is Buckman Labs' K'Netix coupled with its human experts [37]. For instance, a managing director of Asian facilities requested knowledge about pitch-control strategies in that part of the world. Within a few hours, he received 11 suggestions addressing his request and enabling him to secure a US$6 million order.

Table 2
A classification of participants

Composition	Locus	
	Core	Ancillary
Human — Individual	e.g., employee	e.g., individual customer/supplier
Human — Social	e.g., community of practice	e.g., organization that is a customer/supplier
Computer-based	e.g., Decision Support Systems	e.g., Softbots
Hybrid (Human–Computer)	e.g., group working with a GDSS	e.g., Strategic Business Networks [1], Ernie [9]

4.1.1.2. Knowledge artifacts. A knowledge artifact is an object that conveys or holds usable representations of knowledge. However, it does not have any innate knowledge processing capability. Knowledge embodiment in an artifact can be explicit, tacit, or implicit in nature. Common examples of knowledge artifacts are video training tapes, books, memos, business plans in print, manuals, patent documents, filing cabinet contents, facilities, layouts, and products (e.g., knowledge embedded in a manufactured car). An artifact belongs to an organization, but it may be under the control of (or accessible to) only some of its participants.

Knowledge embedded in artifacts can also be represented in other knowledge resources. Representing knowledge as an artifact involves embodiment of that knowledge in an object, thus positively affecting its ability to be transferred, shared, and preserved. For example, Chaparral Steel's near-net-shape casting process, in which both mold and process are patented [24], is represented as two knowledge artifacts: the physical system and a document describing a patented process (thereby preserving and protecting it). It is conceivable that this process knowledge also resides with participants; however, it is the representation as a patent document that furnishes legal protection and preservation.

Organizational knowledge can be expressed in the form of products [46]. Products are not simply a result of material, capital, and labor resources, but also of knowledge resources. Knowledge resources guide the transformation of material, labor, and capital resources into a product. In other words, products in an organization's inventory are artifacts. They are representations of the knowledge used to build them. Once a product is released into the environment, it is no longer an organizational resource. However, these products can be exchanged for other kinds of resources (e.g., financial). A product's exchange value is influenced by what a customer is willing to pay for the knowledge it represents. For example, the value of a can of Coke to a consumer derives largely from the marketing, packaging, and recipe knowledge embodied in it, rather than from the costs of assembling certain ingredients and distributing them in containers. A subtle acknowledgment that knowledge is represented in products can be seen in competitors' attempts at reverse engineering.

4.1.2. Schematic knowledge resources

Schema knowledge is represented or conveyed in the working of an organization. It manifests in the organization's behaviors. Perceptions of schematic knowledge can be captured and embedded in artifacts or participants' memories, but it exists independent of any one participant and artifact. For instance, we may represent culture, infrastructure, purpose, or strategy in an artifact (e.g., documentation), but its existence does not depend on the creation of an artifact. Knowledge about these resources when embedded in artifacts can be subject to rapid selection and formalized internalization. However, aspects of schematic knowledge embodied in an artifact can be different from an organization's actual schema.

Although the four schematic knowledge resources identified in Fig. 2 are interrelated, and good fits among them are important, none can be identified in terms of the others. For instance, a particular culture does not restrict an organization to a particular infrastructure, and vice versa; a given purpose does not define a single potential organization strategy, and vice versa. The schematic resources impact each other and modify each other. For example, a change in purpose could result in a revised strategy, strategies can cause infrastructure revisions, and a particular infrastructure may foster certain cultural characteristics.

4.1.2.1. Culture. Culture is defined by Schein [38] as the "... *basic assumptions* and *beliefs* that are shared by members of an organization, that operate unconsciously, and that define in a basic taken-for-granted fashion an organization's view of itself and its environment." An organization's values, principles, norms, unwritten rules, and procedures comprise its cultural knowledge resource. This resource exists independently of the presence of any particular participant's knowledge, yet it influences each participant's use of knowledge as well as the interactions among participants' knowledge. The cultural resource is comprised of basic assumptions and beliefs that govern participants' activities. It is important for KM researchers and practitioners to appreciate this knowledge resource and the mechanisms whereby it persists and can be altered.

The perspective of culture as a knowledge resource can be recognized by observing participants'

behaviors. For instance, a mill superintendent at Chaparral Steel "championed the ultimately disastrous installation of a US$1.5 million arc saw for cutting finished beams. He was not penalized, but promoted" [24]. This encouraged the values of high tolerance for risk taking and failure. Slowly, the knowledge that a positive attitude towards risk taking is crucial to the organization's success became ingrained in its culture. This knowledge is manifested in the form of frequent experimentation performed by employees to solve problems that allows Chaparral to be innovative and creative.

An organization's cultural knowledge resource impacts participants' behaviors (e.g., knowledge sharing vs. knowledge hoarding). It affects what knowledge is acquired and internalized. Leonard-Barton [24] points out that "Values serve as a knowledge-screening and -control mechanism", That is, the cultural knowledge resource can function as a kind of meta knowledge. It also impacts and is impacted by the other schematic knowledge resources: infrastructure, strategy, and purpose.

4.1.2.2. Infrastructure. Infrastructure is a formal counterpart to an organization's cultural knowledge resource. It is the knowledge that structures an organization's participants in terms of "the roles that have been defined for participants to fill, the relationships among those roles, and regulations that govern the use of roles and relationships" [17]. The roles, relationships, and regulations in force for an organization are knowledge governing the formal structuring of work that is to be performed by its participants. Although it can change over time, this schematic knowledge resource persists even as participants come and go. The infrastructure knowledge resource governs not only ordinary organizational operations, but also the designing, enabling, monitoring, evaluating, enforcing, and modifying of organizational infrastructure itself [17].

Representing knowledge as infrastructure is a means of formalizing existing organizational knowledge that can be used to generate new knowledge [27]. Role definitions are knowledge about what needs to be done by participants, about expectations for the participants assigned to the roles (e.g., what knowledge each is expected to handle or generate). That is, relationships can be implemented technologically, as well as interpersonally. Relationship definitions are knowledge about what interactions are available among participant-filled roles. The interactions that occur for one relationship pattern may generate different knowledge from those that occur for a different pattern. Technology in the guise of communication networks can facilitate particular relationship patterns. Regulation definitions are knowledge about formal rules and procedures that participants are expected to observe in filling their roles and in engaging in relationships. Examples include manufacturing and service processes, hiring processes, performance appraisal, and reward processes.

4.1.2.3. Purpose. Purpose is the schematic knowledge resource that defines an organization's reason for existence. It indicates an organization's mission, vision, objectives, and goals. It strongly influences the other knowledge resources that an organization has or needs to have. The purpose resource guides strategy formulation, the result of which then drives knowledge manipulation activities. If this knowledge is unclear, inadequate, and not carefully evaluated, then an organization may formulate and implement strategies that are detrimental to organizational performance. For example, Sears whose purpose is to sell consumer goods, bought the investment firm Dean Witter. This turned out to be a failure because consumers did not consider their financial needs to be satisfiable by a "consumer product" [8]. In this case, the purpose knowledge resource was inadequate or unused.

4.1.2.4. Strategy. Strategy is the schematic knowledge resource that defines what to do in order to achieve organizational purpose in an effective manner. It is comprised of plans for using an organization's infrastructure, culture, knowledge artifacts, and participants' knowledge (as well as other organizational resources). For instance, these can be plans for promoting a product or achieving effective resource allocation. A purpose of Pepsi and Chaparral Steel is to sustain their leadership positions in their respective markets. However, strategies needed to achieve the same purpose are very different for each firm. Pepsi's strategies focus mainly on gaining competencies in the areas of marketing and sales, whereas Chaparral Steel strategies focus primarily on compe-

tencies that allow it to continually improve and innovate its production processes [24]. In this example, Pepsi and Chaparral Steel have very different sets of strategic knowledge on how to sustain market leadership. Thus, activities for acquiring and cultivating such knowledge would be different for Pepsi and Chaparral Steel.

4.1.3. Environment sources

Aside from its own knowledge resources, an organization's environment holds potential sources of knowledge. Through contacts with its environment, an organization can augment and replenish its knowledge resources. The environment sources do not actually belong to an organization (e.g., in the sense of core participants), nor is it controlled by the organization (e.g., in the sense of ancillary participants). When knowledge is acquired from an environment source, it becomes an organizational resource. This may or may not be difficult or expensive. The World Wide Web is an environment source of knowledge that is relatively easy and inexpensive to tap, albeit of variable quality. Other environment sources include government, media, and university entities whose knowledge is typically available for acquisition by multiple organizations. The Johns Hopkins networked database for genetic research is the "one and only one official record of every gene and piece of DNA that's mapped in the world . . . [It also] capture/s and reflects the ongoing wisdom" of experts from all over the world [3]. Knowledge is acquired from this environment source by thousands of medical researchers and practitioners.

Table 3
Summary of some knowledge attributes

Attribute	Description
Conceptual level [46]	Cognitive level of knowledge: automatic, pragmatic, systematic, goal setting/idealistic.
Content and Application [44]	Knowledge about a certain subject (e.g., customers, suppliers, markets) and problem domain where the knowledge can be used (e.g., marketing, production, logistics).
Degree of abstraction	Ranging from concrete to abstract.
Degree of applicability [31]	How broadly the knowledge can be applied (local or global).
Degree of certainty	Level of confidence in validity of knowledge.
Degree of detail [46]	Extent of depth and breath of knowledge.
Degree of importance [36]	Knowledge significance in value generation relative to ensuring organization's competitiveness (core vs. non-core).
Degree of measurability	Amenability of knowledge to measurement.
Degree of proficiency [46]	Expertise embodied in knowledge.
Degree of recursion	Knowledge, meta knowledge, meta meta knowledge, etc.
Knowledge state [45]	Place in progression of knowledge states: data, information, knowledge, insight/understanding, judgment, decision.
Location [44]	The place (e.g., in terms of knowledge resources, physical position) where knowledge resides.
Management level	The level of management at which knowledge is applicable (strategic, control, operational).
Mode [30,35]	Ranges from tacit to explicit.
Programmability [31]	Extent to which knowledge is transferable and easy to reuse.
Quality [22]	Validity and utility of knowledge.
Source [31]	Origins of the knowledge.
Subject [23]	Knowledge of an application domain, of self, or of others.
Time/Age [44]	Temporal aspects of knowledge.
Type [21,22]	Descriptive, procedural, and reasoning deal respectively with "what," "how," and "why" aspects of knowledge.
Usage [26]	Used for practical, intellectual, pastime, spiritual, pursuits, or for no pursuit (i.e., unwanted).
Volatility	Extent to which knowledge is subject to change.

4.2. Knowledge attributes

A particular knowledge resource, from any of the six classes depicted in Fig. 2 can be characterized in terms of a variety of attributes such as those summarized in Table 3. Awareness of knowledge attributes is beneficial for both researchers and practitioners. Those studying, comparing, or evaluating knowledge resources can do so in terms of one or more knowledge attributes. For instance, all participants' knowledge is not the same. It can differ in type (descriptive, procedural, reasoning), mode (tacit, explicit), quality, volatility, age, and so forth. Such differences may suggest or require different approaches to implementing knowledge manipulation activities within or across classes of knowledge resources. Detailed exploration of knowledge resources and manipulation activities in terms of knowledge attributes is beyond the scope of this paper. We simply note that such an exploration would appear to be a valuable follow-up to the KM framework being developed.

5. Resource framework assessments

The foregoing knowledge resource framework was assessed by panelists both qualitatively and in terms of scaled evaluations for the four criteria. First, we review and discuss qualitative concerns expressed by panelists. Scaled responses reflecting the panelists' degree of satisfaction with the framework are then presented.

5.1. Qualitative evaluation

Evaluation of all the responses to open-ended questions detected no major or crippling reservations about the framework shown in Section 4. Relative to the first round, concerns were not nearly as numerous or as major. Nor was there any recurring theme in the critiques. We concluded that there was little to be gained by putting panelists through additional rounds. For completeness, we report and comment on the relatively minor reservations that were expressed.

KR1: Two of the seventeen respondents commented that they found the characterization of participants to be confusing.

Comment: It may help to present this characterization in an incremental way. First, it can be presented in a simplified form: human vs. computer and core vs. ancillary. Then, complexity can be added by detailing human/computer elements. Additional examples of the various kinds of participants could perhaps add clarity, but at the expense of conciseness.

KR2: Most participants appeared to be satisfied with the overall knowledge resource taxonomy, but there were some isolated reservations. On one hand, participants indicated, "The schema type is very pertinent" and "Liked this section — Intuitive and good face validity." On the other hand, one participant "found this section very difficult to read and [an] unnecessary 'new' framework where a perfectly satisfactory, accepted one already exists." One participant found the taxonomy based on independent vs. dependent notions hard to understand; another did not like the term "schema" (thought that it was misleading) and indicated that "I find your categorization of detailed knowledge resources to be awkward. You seem to be mixing storage media with organizational memory and knowledge schema. Knowledge schema should relate to the categorization of knowledge, i.e., knowledge representations from AI and cognitive science. For example, purpose and strategy are part of meta-knowledge. You need to describe the distinctive characteristics of knowledge as a resource (e.g., multiply in value when used)."

Comment: To persons with a strong, comfortable mindset about knowledge resources, this taxonomy may seem somewhat alien. This may be the source of these three panelists' reservations. Alternatively, their concerns may be addressable by further explanation and detail. In any event, over 80% of the respondents expressed no qualitative reservations about understanding the framework's overall rationale or nature.

KR3: Respondents made the following more detailed, minor points concerning clarification or elaboration:

- "Difficulty in seeing the interrelationships among knowledge resources."
- "Culture is too big a concept and needs decomposing: Norms, behaviors, signs and symbols,

systems, processes, structures, values, and beliefs. Knowledge can also be decomposed: facts, rules, models, cases, experience and concepts."

- "Doubt that the objects [knowledge resources] are discrete and certainly not mutually exclusive." "Consider joining purpose and strategy and joining culture and infrastructure."
- "Information systems (especially organizational memory IS) need more emphasis."
- "Infrastructure term is unclear. The term 'infrastructure' seems to equal the term 'structure'."
- "How purpose differs from vision and mission."

Comment: Beyond its hierarchic structure, the taxonomy does not explore relationships among resource classes. It appears that the taxonomy's identification of classes provides a base for posing and studying models of relationships. It also provides a base for decomposition of each class into more detailed subclasses. In the opposite direction, some users of the framework may prefer to aggregate classes if it suits their needs. Moreover, the framework allows its users to emphasize technologically based knowledge resources to whatever extent is appropriate for their organizations. Every term in the framework is capable of being related to other terms not in the framework. As this could go on indefinitely, it is left to users of the framework to further develop in directions that suit their needs.

KR4: One respondent indicates that there is a role of participants beyond the realm of business organization. "I see this KM framework as particularly descriptive of corporate modes, but not perhaps generic to other kinds of organization in which KM is significant: for example, in revolutionary movements; community of faith; or neighborhood."

Comment: Exploration of this participant role is beyond the business organization research boundary and suggests a future research direction.

KR5: Several panelists volunteered comments indicating that they liked the knowledge attributes section and found it useful. Some suggested expanding it and elaborating. One respondent gives the specific suggestion of using meta-knowledge to describe knowledge context. For instance, "knowledge source (who knows where knowledge is), knowledge validity (date of creation, life), importance (strategic, useful, to keep, to freeze, to cancel), knowledge type (concept, reasoning model, relation, experience, etc.), knowledge domain (be careful it can be useful in many ways), confidentiality, link to information, data, document, and photos."

Comment: Identifying attribute dimensions is not the main focus of the framework, but grew out of round-one critiques. In the interest of conciseness,

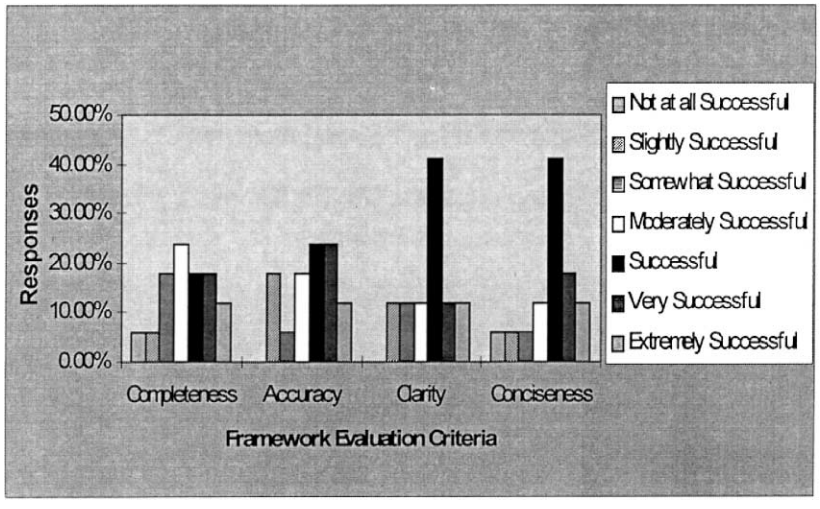

Fig. 3. Responses for each of the framework's criteria.

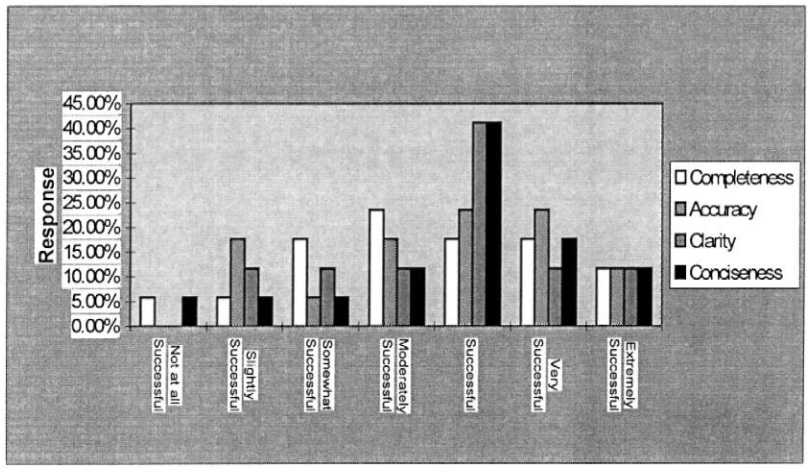

Fig. 4. Responses for each of the evaluation measures.

we have concentrated on identifying attribute dimensions rather than including literature reviews and discussion for each. Given the positive feedback, it would appear to be useful for future research to not only detail each of the attributes for describing a piece of knowledge, but also to seek to add to the attribute list. Users of the framework can augment Table 3 with additional attributes in which they have a particular interest or delve into any of the attributes in more detail. The references given in Table 3 provide a starting point for more detailed treatment of individual attributes.

KR6: One panelist suggested using more figures to illustrate the textual description.

Comment: This is strictly a presentational issue.

5.2. Quantitative evaluation

Each panelist was asked to rate his/her view of the success of the framework with respect to each of the four main criteria: completeness, accuracy, clarity, and conciseness. A seven-point Likert scale was used ranging from "not at all successful" (1) to "extremely successful" (7). Analysis of quantitative responses to Likert-scale items shows that there is a high degree of satisfaction with the framework as presented in this paper. Fig. 3 shows that at least 70% of the respondents indicate a moderate or higher degree of success with respect to each criterion; the proportion exceeds three-fourths for accuracy, clarity, and conciseness. The mode for clarity and conciseness is "successful." The accuracy criterion is bi-modal with modes of "successful" and "very successful." The completeness mode is "moderately successful", with nearly 50% of responses exceeding that level. *A **majority** of respondents gauged the framework's completeness, accuracy, clarity, and conciseness as being in the **successful to extremely successful range***. Fig. 4 presents the frequency distributions for the four criteria. This is an alternative way of looking at results presented in Fig. 3, showing that a heavy preponderance of responses are at least at the moderately successful level across all four criteria.

6. Applying the framework

At the intersection of the resource-based view of organizations and the knowledge-based view of organizations, lies the proposition that knowledge is a key organizational resource and that it can be used for competitive advantage. Research has identified a knowledge chain, comprised of nine KM activities that can be implemented in ways that give organizations competitive advantages in terms of enhanced productivity, agility, innovation, and reputation [18,39]. However, aside from KM activities per-

formed by an organization's processors, the classes of knowledge resources identified here are potential sources of competitive advantage. This contention can be investigated from the standpoints of which individual knowledge resource classes can be devised in such a way that contributes to an organization's competitiveness (and how so), what portfolio mixes across the classes tend to yield competitive advantages, and what specific practices for KM activities combine with what specific knowledge resource portfolios to enhance competitiveness.

Successful decision making is essential for competitiveness. The organizational knowledge resource framework identifies the classes of knowledge resources that deserve consideration in efforts to make an organization's decision making more successful. The participant knowledge embodied in DSSs certainly fits within this big picture. Similarly, human participants' knowledge also comes into play. This is consistent with the notion of human decision support systems (HDSSs) [22]. The framework suggests several interesting research questions. For a given set of schematic knowledge resources, what mix of DSSs and HDSSs is desirable? What tradeoffs exist between representing knowledge in a DSS vs. an HDSS? What kinds of DSSs work best in the context of a particular set of cultural, infrastructure, strategy, and purpose knowledge resources? Where does the knowledge system of a DSS fall on the various knowledge attribute dimensions? How does a DSS knowledge resource interact with other kinds of organizational knowledge resources and how should it do so?

Efforts at measuring an organization's knowledge resources should cover each of the taxonomy's classes and may proceed along multiple attribute dimensions. Different measures may be required across, or even within, different classes. Similarly, efforts at controlling the validity and utility of knowledge may depend on the class in which that knowledge exists. The taxonomy identifies classes that are candidates for organizing or inclusion in comprehensive knowledge maps. Researchers need to study and practitioners need to understand the implementation of each knowledge manipulation activity (i.e., acquisition, selection, internalization, generation, and externalization) as it operates on each class.

Each of the knowledge resources identified in this taxonomy is a concept that can be analyzed further, perhaps yielding another layer at the bottom of the hierarchy in Fig. 2. For instance, culture may be further decomposed into norms, shared beliefs, values, and traditions. Artifacts might be further categorized as products, buildings, documents, books, audio tapes, video tapes, patent documents, and so forth.

7. Conclusion

This paper develops a framework that identifies and characterizes classes of organizational resources, and identifies knowledge attributes that can be used across classes in describing the nature of knowledge. Broadly, knowledge resources can be classified as those that depend on an organization for existence (schematic resources) and those that exist independent of an organization (content resources). These collectively form an organization's knowledge resources. Future research may extend and/or revise this taxonomy or apply it in addressing a variety of KM issues such as those described in the previous section.

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