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A Model of Organizational Knowledge Management Maturity based on People, Process, and Technology

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Abstract

Organizations are increasingly investing in knowledge management (KM) initiatives to promote the sharing, application, and creation of knowledge for competitive advantage. To guide and assess the progress of KM initiatives in organizations, various process models have been proposed but a consistent approach that has been empirically tested is lacking. Based on the life cycle theory, this paper reviews, compares, and integrates existing models to propose a General KM Maturity Model (G-KMMM). G-KMMM encompasses the initial, aware, defined, managed, and optimizing stages, which are differentiated in terms of their characteristics related to the people, process, and technology aspects of KM. To facilitate empirical validation and application, an accompanying assessment tool is also developed. As an initial validation of the proposed G-KMMM, a case study of a multi-unit information system organization of a large public university was conducted. Findings indicate that G-KMMM can be a useful diagnostic tool for assessing and guiding KM implementation in organizations.

Keywords: Knowledge Management, Maturity Modeling, Case Study

1. Introduction

Organizations are realizing that knowledge management (KM) is essential for them to remain agile in a dynamic business environment and are increasingly investing in various KM initiatives. It is estimated that companies in the United States spent close to $85 billion on KM in 2008, an increase of nearly 16 percent from 2007 (AMR Research, 2007). Federal government investment on KM is also expected to increase by 35 percent from 2005 to reach $1.3 billion by 2010 (INPUT, 2005). Recognizing that KM is a complex undertaking involving people, process, and technology, there is increasing need for a coherent and comprehensible set of principles and practices to guide KM implementations (Pillai et al. 2008; Wong and Aspinwall, 2004). To better understand the ongoing development of KM in organizations, this study adopts the perspective of life cycle theory to describe the process through which KM is explicitly defined, managed, controlled, and effected in knowledge-intensive organizations.

Life cycle theory adopts the metaphor of organic growth to explain the development of an organizational entity. It suggests that change is imminent and an entity moves from a given point of departure toward a subsequent stage that is prefigured in the present state (Van de Ven and Poole, 1995). Life cycle theories of organizational entities have depicted development in terms of institutional rules or programs based on logical or natural sequences. For example, in information system (IS) research, one of the best known models by Nolan (1979) describes six stages of growth of electronic data processing (EDP), encompassing initiation, contagion, control, integration, data administration, and maturity. These stages are ordered by both logic and natural order of business practices. By organizing and representing data processing and management practices in a coherent structure, the model has contributed significantly to our understanding of data management and has become a recognized management concept in IS research.

The wide acceptance and application of Nolan's model demonstrate that life cycle theory is a valuable approach for describing the development of IS. As information technology transforms from providing basic data processing support to playing a more central role in organizations, other life cycle models have been developed to depict the evolution of more advanced systems such as end-user computing (Henderson and Treacy, 1986; Huff et al., 1988) and enterprise resource planning systems (Holland and Light, 2001).

In the realm of KM, various life cycle models have also been proposed. They are commonly known as KM maturity models (KMMM) (e.g., Gottschalk and Khandelwal, 2004; Lee and Kim, 2001). These models are generally unitary (single sequence of stages), cumulative (characteristics acquired in earlier stages are retained in later stages), and conjunctive (stages are related in that they are derived from a common underlying structure) sequence as characteristics of life cycle theory (Van de Ven and Poole, 1995). However, different models adopt diverse concepts and are based on different assumptions. This makes their selection, comparison, and application difficult for both researchers and practitioners. To develop a more consistent and widely-accepted view of KM development, it is imperative to sift through the various conceptualizations to identify the most central issues in KM development. To this end, we review, compare, and integrate existing KMMMs to identify the core elements of a KM development life cycle. A General Knowledge Management Maturity Model (G-KMMM) is then proposed to describe the process and highlight the key aspects of KM development.

Existing KMMMs have been criticized as ad-hoc in their development (Kulkarni and St. Louis, 2003) because their assessment tools are either proprietary or unspecified, rendering their empirical assessment difficult. As a result, most KMMMs have not been validated (Kulkarni and St. Louis, 2003) and there are reservations regarding their practical applicability and the extent to which they reflect the actual state of affairs. This paper addresses the gap by proposing an assessment tool accompanying the proposed G-KMMM. As an initial validation of the proposed model and assessment tool, we also conducted an exploratory case study of the KM initiative of an IS organization in a large public university.

Through this endeavor, we hope to contribute to research and practice in several ways. For research, this study provides a systematic review and comparison of existing KMMMs, which can potentially add to the cumulative knowledge of life cycle theory in general and KM development in particular. The proposed G-KMMM also avoids oversimplifying the phenomenon of KM development in organizations by adopting a multidimensional approach encompassing people, process, and technology aspects. By synthesizing findings from previous research and clearly defining important concepts, the proposed G-KMMM can facilitate communication and improve understanding among researchers and practitioners.

For organizations engaging in KM initiatives, G-KMMM can be used to track the ongoing development of KM initiatives or benchmark and compare the progress of different units. Unlike prior work, this paper clearly defines the components of KMMM and develops an accompanying assessment instrument, which allows the model to be independently assessed and applied by researchers and practitioners. By highlighting the important issues in KM development, G-KMMM can also assist managers in their planning of KM initiatives.

2. Conceptual Background

This section first defines the concepts of KM and maturity modeling. Existing KMMMs are then reviewed and compared.

2.1 Knowledge and Knowledge Management

In the context of organizations, knowledge is defined as a justified belief that increases an entity's capacity for effective action (Huber, 1991). This definition is deemed to be more appropriate than a philosophical definition of knowledge because it provides a clear and pragmatic description of knowledge underlying organizational knowledge management

(Alavi and Leidner, 2001), which is the entity of interest in this study. In a similar vein, knowledge management refers to the process of identifying and leveraging collective knowledge in an organization to help the organization compete (Alavi and Leidner, 2001).

Knowledge is often conceptualized as the most valuable form of content in a continuum beginning with data, encompassing information, and ending at knowledge (Grover and Davenport, 2001). Although information and knowledge are related, it is important to distinguish KM, both as an area of scholarly enquiry and as a business practice, from the concept of information management (IM). While KM presupposes IM (Klaus and Gable, 2000) and the success of KM depends on effective IM (Bukowitz and Williams, 2000), they are different in terms of input, processing of data and information, and scope. With respect to input, KM requires ongoing user contribution, feedback, and human input whereas IM typically involves one-way information transfer and assumes that information capture can be standardized and automated. In the processing of data and information, KM supports performance improvement and innovation through adding value to data by filtering, synthesizing, and exploration while IM supports existing operations by formatting and presenting existing data (Bukowitz and Williams, 2000). In terms of scope, IM is usually concerned with storing and disseminating electronic and paper-based information, while KM deals with a far broader range of approaches to communicating, applying, and creating knowledge and wisdom (Bukowitz and Williams, 2000).

2.2 Knowledge Management Models

Existing KM models are developed based on different theories and methods and they vary greatly in terms of focus and scope. In general, they can be categorized as process-oriented, social/technological enabler, contingency, and knowledge-oriented models (Alavi and Leidner, 2001; Handzic et al., 2008). Process-oriented models examine the processes of knowledge capturing, sharing, application, and creation to understand the mechanisms through which value is derived from knowledge; models of social/technological enabler identify the factors that may affect the adoption and success of KM tools and practices; contingency models recognize that the success of KM initiatives depends on the context in which they are implemented; knowledge-oriented models focus on the exploitation of knowledge assets and assessment of the value of intellectual capital.

By identifying the key practices in people, process, and technology aspects that can propel the development of KM in organizations, the proposed G-KMMM links and combines the perspectives adopted by existing process-oriented and social/technological enabler models in a single framework. G-KMMM also concurs with the contingency perspective in underlining the importance of people and process aspects in assessing KM maturity. The model recognizes that KM maturity does not automatically follow the adoption of sophisticated KM technology. Instead, it is contingent upon the people and processes characterizing the context in which it is adopted. As with knowledge-oriented models, G-KMMM is developed based on the premise that knowledge is a valuable asset that mature organizations can effectively capitalize to improve organizational performance and yield profit. Unlike these models, G-KMMM also emphasizes the evolutionary nature of KM where implementation efforts build on one another, as discussed next.

2.3 Maturity Model and KM Maturity

Akin to the life cycle theory, a *maturity model* describes the development of an entity over time and has the following properties (Klimko, 2001; Weerdmeester et al., 2003): an entity's development is simplified and described with a limited number of maturity levels (usually four to six), levels are ordered sequentially and characterized by certain requirements that the entity must achieve, and the entity progresses from one level to the next without skipping any level.

Maturity models have been developed for many different entities, including IS. One of the best known models is the stages of growth of EDP (Nolan, 1979). The model identifies various organizational issues in IS implementation and development and highlights the priorities requiring managerial attention at different stages of growth. It has stimulated much interest among IS scholars (e.g., Benbasat et al., 1984; Henderson and Treacy, 1986; Kazanjian and Drazin, 1989) and is considered a significant conceptual contribution that promotes a more structured approach to studying IS in organizations (King and Kraemer, 1984).

In this study, we focus on modeling the maturity of KM systems and initiatives. We define KM maturity as the extent to which KM is explicitly defined, managed, controlled, and effected. It describes the stages of growth of KM initiatives in an organization. KMMMs will be discussed in greater detail in the following sections.

2.4 Characteristics of an Ideal KMMM

To ensure that KMMMs adequately portray the development of KM in organizations, past studies have identified several requirements that an ideal KMMM should fulfill (Ehms and Langen, 2002; Paulzen and Perc, 2002). It has been suggested that KMMM should be applicable to different objects of analysis such as the organization as a whole, traditional and virtual organizational units, and KM systems (Ehms and Langen, 2002). This can be achieved by focusing on processes rather than specific objects of analysis (Paulzen and Perc, 2002).

It has also been recommended that KMMMs should provide a systematic and structured procedure to ensure the transparency and reliability of assessment (Ehms and Langen, 2002). The maturity model should also provide both qualitative and quantitative results (Ehms and Langen, 2002). Paulzen and Perc (2002) emphasized the importance of measurement and echoed the suggestion that the characteristics of each maturity level should be empirically testable (Magal, 1989). In IS research, the lack of a clearly specified assessment procedure for Nolan’s model has been identified as one of the reasons for its validation to be inconclusive (Benbasat et al., 1984; Kazanjian and Drazin, 1989). Clearly articulating the assessment procedure can help to avoid such a problem by allowing independent application and validation.

In addition, it has been suggested that the underlying structure of KMMM should be comprehensible and allow cross references to proven management concepts or models (Ehms and Langen, 2002) to support continuous learning and improvement (Paulzen and Perc, 2002). This can be achieved by reviewing existing literature to identify salient KM issues and incorporate the findings into the development of the KMMM.

Other than identifying the criteria for an ideal KMMM, it is also important to consider the criticisms of IS maturity models in general, since an ideal KMMM should also avoid these weaknesses. Specifically, Nolan's model has been criticized as being overly simplistic for focusing on technology and overlooking development in other organizational aspects (Lucas and Sutton, 1977). Therefore, it is important for the proposed KMMM to look beyond technology. Indeed, it has been suggested that KM models should adopt a multifaceted and socio-technical view of organizations by considering not just the technology but also its people and processes (Alavi and Leidner, 2001; Apostolou et al., 2008-2009).

In reality, it can be challenging for a KMMM to satisfy all the requirements. One reason is that some requirements may require tradeoff with other requirements when implemented together. For example, Ehms and Langen (2002) have suggested that KMMM should ideally be applicable to different objects of analysis. This may require higher level of flexibility in the model's formulation which may result in a less systematic assessment approach. Hence, it is important to strike a balance among these requirements.

To identify important issues in the KM development lifecycle, we review existing KMMMs that have been proposed and refined by KM researchers and practitioners. For ease of comparison, they are categorized into two groups, depending on whether or not they are developed based on the Capability Maturity Model (CMM).

2.5 KMMMs based on the Capability Maturity Model (CMM)

CMM is proposed to describe and determine the software engineering and management process maturity of an organization. Its main purpose is to guide software organizations in progressing along an evolutionary path from ad-hoc and chaotic software process to mature and disciplined software process (Herbsleb et al., 1997). The model has gained considerable acceptance worldwide and has been regarded by many as the industry standard for defining software process quality. Like many other concepts that originated from practice, empirical assessment of CMM by researchers lagged its adoption in organizations. Nevertheless, its widespread adoption has allowed realistic evaluations to be conducted and many peer-reviewed studies of CMM have provided empirical evidence of its validity in describing and guiding the development of software organizations (e.g., Lawlis et al., 1995; McGarry et al., 1998).

CMM defines five levels of maturity: initial, repeatable, defined, managed, and optimizing. Each maturity level is described by a set of characteristics. For example, the level “initial” is characterized as ad-hoc and chaotic, where few processes are defined and success is due to individual effort. Except for level 1, several key process areas (KPA) are identified at each maturity level to indicate the areas that an organization should focus on. Each KPA is further described in terms of actionable practices.

Although CMM was originally proposed to describe software processes, it has been adapted to develop several KMMMs, based on the premise that software process management can be considered as a specific instance of KM and the concepts proposed in CMM may therefore be also appropriate to describe KM (Armour, 2000; Paulzen and Perc, 2002). However, several differences between software process management and KM are worth noting. KM covers a wider range of issues and is less structured compared to software process management. Its activities are also less standardized and outcomes are less quantifiable. Hence, KM maturity must be judged from multiple perspectives, including technologies, processes, and employees, in order to achieve a holistic assessment of KM development. Consequently, KMMMs have KPAs that are somewhat different from CMM (Kulkarni and Freeze, 2004).

In our review, four KMMMs based on CMM were identified: Siemens' KMMM, Paulzen and Perc's Knowledge Process Quality Model (KPQM), Infosys' KMMM, and Kulkarni and Freeze's Knowledge Management Capability Assessment Model (KMCA). All four models are developed based on CMM and thus have similar structures. The naming of maturity levels in the four KMMMs are compared in Table 1.

Table 1. Naming of Maturity Levels of CMM-Based KMMMs

Level	**CMM**	**CMM-Based KM Maturity Models**			
		Siemens' KMMM	**KPQM**	**Infosys' KMMM**	**KMCA**
0	-				Difficult / Not Possible
1	Initial	Initial	Initial	Default	Possible
2	Repeatable	Repeatable	Aware	Reactive	Encouraged
3	Defined	Defined	Established	Aware	Enabled / Practiced
4	Managed	Managed	Quantitatively Managed	Convinced	Managed
5	Optimizing	Optimizing	Optimizing	Sharing	Continuously Improving

Each maturity level of these models is further described by a set of characteristics (see Table 2). However, it was observed that different KMMMs specified different characteristics. Through careful analysis and consolidation of the characteristics in Table 2, a set of characteristics that are repeatedly highlighted by different models were identified to represent the important aspects of each KM maturity level (see Table 3).

Table 2. Characteristics of Maturity Levels of CMM-Based KMMMs

Level	Siemens' KMMM	KPQM	Infosys' KMMM	KMCA
0	-			- Lack of identification of knowledge assets - Knowledge sharing discouraged - General unwillingness to share knowledge - People do not seem to value knowledge sharing
1	- Lack of awareness of the need to manage knowledge - No conscious control of knowledge processes - KM unplanned and random			- Knowledge sharing is not discouraged - General willingness to share knowledge - People who understand the value of knowledge sharing share their knowledge - Knowledge assets are recognized / identified
2	- Awareness of the need to manage organizational knowledge - Value of knowledge assets recognized by organization			
	- Pilot KM projects and "pioneers" exist	- First structures defined - Processes planned and documented - Structures to establish awareness of KM methods in organization - Partial technological support for KM methods	- Only routine and procedural knowledge shared - Knowledge sharing is on need basis - Basic knowledge-recording systems exist	- Organization's culture encourages all activities related to sharing of knowledge assets - Leadership / senior management communicates value of and shows commitment to knowledge sharing - Sharing is recognized / rewarded - Explicit knowledge assets are stored - Tacit and implicit knowledge are tracked
3	- Stable and "practiced" KM activities that are integrated with everyday work process - Activities support KM in individual parts of the organization - Relevant technical systems are maintained - Individual KM roles are defined	- Systematic structure and definition of knowledge processes - Processes tailored to meet special requirements - Incentive system defined - Individual roles are defined - Systematic technological process support exists	- Basic knowledge infrastructure established but knowledge is not integrated - Initial understanding of KM metrics - KM activities translated to productivity gains - Managers recognize their role in and actively encourage knowledge sharing	- Sharing of knowledge is practiced - Leadership / senior management sets goals with respect to knowledge sharing - KM activities are part of normal workflow - KM systems / tools and mechanisms enable activities with respect to knowledge sharing - Centralized repositories and knowledge taxonomies exist
4	Use of metrics to measure and evaluate success		- Use of metrics (project / function level)	- Employees find it easy to share knowledge assets - Employees expect to be successful in locating knowledge assets - Knowledge sharing formally / informally monitored and measured - Training and instruction on KMS usage is provided - Use change management principles in introducing KM - KM tools are easy to use
	- Common strategy and standardized approaches towards KM - Organizational standards	- Improve systematic process management - Incentives quantitatively managed - Impact of technological support is evaluated quantitatively	- KM is self-sustaining - Enterprise-wide knowledge sharing systems in place - Able to sense and respond to changes	
5	- Continuous improvement - Flexible to meet new challenges			- Mechanisms and tools to leverage knowledge assets are widely accepted - Systematic effort to measure and improve knowledge sharing - KM tools periodically upgraded / improved - Business processes that incorporate sharing of knowledge assets are periodically reviewed
	Metrics are combined with other instruments for strategic control	- Structures for self-optimization exist - Technologies for process support are optimized on a regular basis - Pilot projects are performed	- Culture of sharing is institutionalized - Sharing is second nature - ROI-driven decision making - Organization a knowledge leader	

Table 3. Common Characteristics of Maturity Levels of CMM-Based KMMMs				
Characteristic	**Siemens' KMMM**	**KPQM**	**Infosys' KMMM**	**KMCA**
Lack of awareness of the need for KM	Level 1	Level 1	Level 1	Level 1
Aware of the importance of KM to organization	Level 2	Level 2	Level 2	Level 2
Basic KM infrastructure in place	Level 3	Level 2	Level 3	Unspecified. Probably Level 3
KM activities are stable and practiced	Level 3	Unspecified. Probably Level 3	Level 4	Level 3
Individual KM roles are defined	Level 3	Level 3	Level 2 (knowledge database administrator) and level 3 (dedicated KM group)	Unspecified. Probably Level 3
Management realizes their role in, and encourages KM	Unspecified. Probably Level 3	Unspecified. Probably Level 3	Level 3	Level 2
Training for KM	Unspecified. Probably Level 3	Unspecified. Probably Level 3	Level 3 and level 4	Level 4
Common organizational KM strategy	Level 4	Unspecified. Probably Level 3	Level 4	Unspecified. Probably Level 4
Use of metrics to govern KM	Level 4	Level 4	Level 3 (productivity gains), level 4 (project/function-level), and level 5 (organization-level)	Level 5
Continual improvement of KM practices and tools	Level 5	Level 5	Level 5	Level 5
Existing KM can be adapted to meet new challenges	Level 5	Unspecified. Probably Level 5	Level 5	Unspecified. Probably Level 5

Each KMMM also identified KPAs to indicate the areas that an organization should focus on in its KM development (see Table 4). Different KMMMs have specified different KPAs, with people, organization, process, and technology being the most common across models.

<table>
<tr><th colspan="5">Table 4. KPAs of CMM-Based KMMMs</th></tr>
<tr><th>KMMM</th><th colspan="3">Key Process Areas</th><th>Remarks</th></tr>
<tr><td>Infosys' KMMM</td><td>People</td><td>Process</td><td>Technology</td><td>Infosys' KMMM does not differentiate between the 3 KPAs at maturity level 5</td></tr>
<tr><td rowspan="2">Siemens' KMMM</td><td colspan="2">- Process, roles, and organization
- Strategy and knowledge goals</td><td rowspan="2">Technology and infrastructure</td><td rowspan="2">-</td></tr>
<tr><td>- Staff and competencies
- Cooperation and culture
- Leadership and support
- Environment and partnerships</td><td>Knowledge structures and knowledge forms</td></tr>
<tr><td>KPQM</td><td>People</td><td>Organization</td><td>Technology</td><td></td></tr>
<tr><td>KMCA</td><td colspan="3">- Lessons-learned
- Expertise
- Data
- Structured knowledge</td><td>Perceptual (behavioral) and factual (infrastructure-related) characteristics are identified for each of the 4 KPAs</td></tr>
</table>

2.6 Non-CMM-Based KMMMs

Six KMMMs that are not based on CMM were identified: KPMG Consulting's Knowledge Journey (KPMG Consulting, 2000), TATA Consultancy Services' 5iKM3 (Mohanty and Chand, 2004), Klimko's KMMM (Klimko, 2001), WisdomSource's K3M (WisdomSource, 2004), Gottschalk and Khandelwal's Stages of Growth for KM Technology (Gottschalk and Khandelwal, 2004), and VISION KMMM (V-KMMM) (Weerdmeester et al., 2003). Among these models, Gottschalk and Khandelwal's model and V-KMMM define four levels of maturity; Knowledge Journey, 5iKM3, and Klimko's KMMM defines five levels of maturity; and WisdomSource's K3M defines eight levels of maturity (see Table 5). Unlike the other five KMMMs, V-KMMM does not follow a progressive maturity pathway. Hence, it was not considered in our comparison of non-CMM-based KMMMs.

Table 5. Naming of Maturity Levels of Non-CMM-Based KMMMs

Level	Knowledge Journey	5iKM3	Klimko's KMMM	K3M	Stages of Growth for KM Technology
1	Knowledge chaotic	Initial	Initial	Standardized infrastructure for knowledge sharing	End-user tools (people-to-technology)
2	Knowledge aware	Intent	Knowledge discoverer	Top-down quality-assured information flow	Who knows what (people-to-people)
3	Knowledge focused	Initiative	Knowledge creator	Top-down retention measurement	What they know (people-to-docs)
4	Knowledge managed	Intelligent	Knowledge manager	Organizational learning	What they think (people-to-systems)
5	Knowledge centric	Innovative	Knowledge renewer	Organizational knowledge base / intellectual property maintenance	-
6	-			Process-driven knowledge sharing	
7				Continual process improvement	
8				Self-actualized organization	

Similar to CMM-based KMMMs, each maturity level of the non-CMM-based KMMMs is described by a set of characteristics (see Table 6). Among the models, K3M define finer levels of maturity compared to other KMMMs. Hence, in our comparison in Table 6, characteristics of several levels of K3M are sometimes observed to be comparable to a single level of other KMMMs. In addition, K3M and the Stages of Growth for KM Technology models lack the first level and they were thus excluded from our comparison at that level.

<table>
<tr><th colspan="6">Table 6. Characteristics of Non-CMM-Based KMMMs</th></tr>
<tr><th>Level</th><th>Knowledge Journey</th><th>5iKM3</th><th>Klimko's KMMM</th><th>K3M</th><th>Stages of Growth for KM Technology</th></tr>
<tr><td rowspan="2">1</td><td colspan="3">Lack of awareness of the need to manage knowledge</td><td rowspan="2">-</td><td rowspan="2">-</td></tr>
<tr><td>Does not demonstrate relationship between importance of KM and achievement of organizational goals</td><td>No formal processes for using organizational knowledge effectively for business delivery</td><td>- Does not pay specific attention to KM activities
- KM is considered as information management</td></tr>
<tr><td rowspan="2">2</td><td colspan="3">Awareness of the need to manage organizational knowledge</td><td rowspan="2">- Content publishing and management system in place (level 1)
- Information is digitized and delivered from managers to staff via structured e-mail broadcasts and web portals (level 2)
- Clearly defined roles and deliverables (level 2)
- Individuals are aware that they are accountable for achieving goals set by the management (level 2)</td><td rowspan="2">Widespread dissemination and use of end-user tools among knowledge workers in the company.</td></tr>
<tr><td>- Awareness and implementation of KM across the organization may not be uniform
- Pilot projects exists in some areas</td><td>Organization realizes the potential in harnessing its organizational knowledge for business benefits</td><td>- Focus on internals (defining, scanning, codifying, and distributing knowledge)
- KM still considered information management
- Challenge is to codify and deploy discovered knowledge</td></tr>
<tr><td>3</td><td>- Organization uses KM procedures and tools
- Organization recognizes that KM brings some benefits to the business</td><td>- Organizations have knowledge enabled their business processes
- Organizations are observing benefits and business impacts from KM</td><td>- Focus on externals (management commitment, understanding business needs, innovation)
- Focus on creating knowledge that is of interest to future business needs
- Broad-based approach to KM, technology is secondary
- Challenge is to understand future business needs and make forecasts on business environment</td><td>- Measure retention of information delivered to staff via collection tools (level 3)</td><td>Knowledge workers use IT to find other knowledge workers. It aims to record and disclose who in the organization knows what by building knowledge directories.</td></tr>
<tr><td>4</td><td>- Has integrated framework of KM procedures and tools
- Some technical and cultural issues need to be overcome</td><td>- Has matured collaboration and sharing throughout the business processes
- KM has resulted in collective and collaborative organizational intelligence</td><td>- Institutionalized (document processes, promote sharing, manage resources, utilize sophisticated technology)
- Individuals and organizational units dedicated to KM
- KM has formal documented processes
- Knowledge processes are measurable, quantitative control is possible
- KM interfaces with quality management function
- Challenge is to integrate existing and created knowledge, and to institutionalized KM processes</td><td>- Digitizing and just-in-time delivery of information (level 4)
- Measure retention (level 4)
- Maintain up-to-date repository of organizational documents (level 4)
- Gather, organize, improve, and maintain individual and collective processes via secure, internal, and customizable web portals (level 5)
- Capture and just-in-time delivery of up-to-date work processes organized by role (level 6)</td><td>IT provides knowledge workers with access to information that is typically stored in documents and made available to colleagues. Here data mining techniques will be applied to store and combine information in data warehouses.</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">- KM procedures are an integral part of organizational and individual processes
- Value of knowledge is reported to the stakeholders</td><td colspan="2">Continuous improvement</td><td rowspan="2">- Knowledge collection tools capture feedback, best practices, and lessons learned from resources at the front line (level 7)
- Knowledge is shared, reused, analyzed, and optimized (level 7)
- KM provides online virtual representation of the organization and its functional units (level 8)
- KMS forms the structural backbone for enterprise-wide innovation and employee self-actualization (level 8)
- Continuous filtering out of non-value-added work (level 8)</td><td rowspan="2">The system is intended to help solve a knowledge problem. Artificial intelligence will be applied in these systems.</td></tr>
<tr><td>KM is institutionalized</td><td>Focus on inter-organizational co-operation and exploit common ways of knowledge creation</td></tr>
</table>

We observed that there are relatively less similarities across the non-CMM-based KMMMs as compared to the CMM-based KMMMs. However, many of the common characteristics of CMM-based KMMMs in Table 3 are also observed in the non-CMM-based KMMMs. For example, all non-CMM-based KMMMs that have defined level 1 characterized it by organization's lack of awareness of the need to manage knowledge formally and level 2 by the presence of such awareness. Also, the need to have basic KM infrastructure at level 3 is strongly implied in all non-CMM-based KMMMs.

In addition, we observed that all non-CMM-based KMMMs (except Klimko's KMMM which does not identify any KPA and the Stages of Growth for KM Technology model which focuses on technological aspects) identify KPAs that are largely similar to CMM-based models, which includes people, process, and technology (see Table 7). Based on these comparisons, a general KMMM was proposed, as discussed next.

Table 7. KPAs of Non-CMM-Based KMMMs

KMMM	**Key Process Areas**			**Remarks**
V-KMMM	Culture	Infrastructure	Technology	-
The Knowledge Journey	People	Process and content	Technology	-
5iKM3	People	Process	Technology	-
K3M	Process and technology			-Model focuses on technological aspects -People aspects are described from a technological perspective
Stages of Growth for KM Technology	-		Technology	-Model focuses solely on technological aspects

3. Proposed General KMMM (G-KMMM)

Akin to the life cycle theory and the majority of existing KMMMs, the proposed G-KMMM follows a staged structure and has two main components: maturity level and KPA. Each maturity level is characterized in terms of three KPAs (people, process, and technology), and each KPA is described by a set of characteristics. These characteristics specify the key practices that, when collectively employed, can help organizations accomplish the goals of a particular maturity level.

3.1 Maturity Levels in G-KMMM

G-KMMM defines five levels of maturity: initial, aware, defined, managed, and optimizing (see Table 8). Organizations at the *initial* level have little or no intention to formally manage knowledge as it is not explicitly recognized as essential to their long-term success. At the *aware* level, organizations are aware of the significance of knowledge and have the intention to manage it formally, but may not know how to do so. Organizations at this level often initiate various pilot projects to explore the potential of KM. Organizations at the *defined* level have basic infrastructures supporting KM, with management actively promoting KM by articulating KM strategy and providing training and incentives. In these organizations, formal processes for creating, capturing, sharing, and applying both formal and informal knowledge are specified. Pilot projects exploring more advanced KM applications are also carried out. At the *managed* level, KM is tightly incorporated into organizational strategy and is supported by enterprise-wide KM technology. KM models and standards such as those integrating knowledge flows with workflows are also adopted. In addition, quantitative measures are utilized to assess the effectiveness of KM. At the *optimizing* level, organizations have KM systems that closely support key business activities. With an institutionalized knowledge-sharing culture, organizational members, while not expected to share every single piece of their knowledge, are willing to contribute unique and valuable knowledge that is central to the activities of the organization.

Table 8. Proposed G-KMMM					
Maturity Level		General Description	Key Process Areas		
			People	Process	Technology
1	Initial	Little or no intention to formally manage organizational knowledge	Organization and its people are not aware of the need to formally manage its knowledge resources	No formal processes to capture, share and reuse organizational knowledge	No specific KM technology or infrastructure in place
2	Aware	Organization is aware of and has the intention to manage its organizational knowledge, but it might not know how to do so	Management is aware of the need for formal KM	Knowledge indispensable for performing routine task is documented	Pilot KM projects are initiated (not necessarily by management)
3	Defined	Organization has put in place a basic infrastructure to support KM	- Management is aware of its role in encouraging KM - Basic training on KM are provided (e.g., awareness courses) - Basic KM strategy is put in place - Individual KM roles are defined - Incentive systems are in place	- Processes for content and information management is formalized - Metrics are used to measure the increase in productivity due to KM	- Basic KM Infrastructure in place (e.g., single point of access) - Some enterprise-level KM projects are put in place
4	Managed	KM initiatives are well established in the organization	- Common strategy and standardized approaches towards KM - KM is incorporated into the overall organizational strategy - More advanced KM training - Organizational standards	Quantitative measurement of KM processes (i.e., use of metrics)	- Enterprise-wide KM systems are fully in place - Usage of KM systems is at a reasonable level - Seamless integration of technology with content architecture
5	Optimizing	- KM is deeply integrated into the organization and is continually improved upon - It is an automatic component in any organizational processes	Culture of sharing is institutionalized	- KM processes are constantly reviewed and improved upon - Existing KM processes can be easily adapted to meet new business requirements - KM procedures are an integral part of the organization	Existing KM infrastructure is continually improved upon

G-KMMM proposes that organizations should progress from one maturity level to the next without skipping any level. In practice, organizations may beneficially employ key practices characterizing a higher maturity level than they are at. However, being able to implement practices from higher maturity levels does not imply that levels can be skipped since they are unlikely to attain their full potential until a proper foundation is laid.

3.2 Key Process Areas in G-KMMM

Based on our review of existing KMMMs, important KPAs in KM development are people, process, and technology (see Table 8). These KPAs concur with past studies' suggestion that KM needs to consider human (i.e., psychological and sociological), task or process, and technological aspects in order to deliver thorough and successful business support (Powers, 1999). Such a multifaceted view is also recommended by critics of Nolan's stages of growth model, which was considered as limited by its focus on technology as the main determinant of IS maturity (Kazanjian and Drazin, 1989). In the G-KMMM, the people KPA includes aspects related to organizational culture, strategies, and policies; the process KPA refers to aspects concerning KM activities such as sharing, application, and creation of knowledge; and the technology KPA relates to aspects about KM technology and infrastructure. Understanding KM maturity from these different perspectives is expected to provide a comprehensive overview.

In the G-KMMM, each KPA is described by a set of characteristics. At this point it is useful to reemphasize that many of the common characteristics of CMM-based KMMMs in Table 3 are also seen or strongly implied in the majority of non-CMM-based KMMMs. This suggests that the common characteristics of CMM-based KMMMs in Table 3 are fairly representative of KMMMs in general. Consequently, the characteristics describing each KPA at each maturity level in G-KMMM correspond largely to those presented in Table 3.

3.3 KM Maturity Assessment Instrument

To facilitate independent validation and practical application of the G-KMMM, an accompanying assessment instrument was developed. The KM maturity of an organization is indicated by the extent to which an organization successfully accomplished all the key practices characterizing a maturity level (see Table 9). Questions used in the assessment instrument were adapted from related literature and existing instruments when available (proprietary assessment tools were not accessible) and appropriate. Sources included the Knowledge Journey's KM Framework Assessment Exercise, KPQM, KMCA, and KM Assessment Tool (American Productivity and Quality Center and Arthur Andersen, 1996; de Jager, 1999). KM Assessment Tool (KMAT) is a diagnostic survey that helps an organization determines the effectiveness of its KM practices. When suitable items could not be found in existing literature, new items were developed based on the proposed model (see Table 8) (i.e., PEO3b, PEO3c, PEO3f, PRO3a, and TEC4b). Among the five newly developed items, three items measure the people KPA. This indicates that existing assessment tools may have neglected this aspect compared to the technology and process aspects.

Table 9. Proposed G-KMMM Assessment Instrument

Level	Question	Source
KPA: People		
2	***PEO2a*** Is organizational knowledge recognized as essential for the long-term success of the organization?	Knowledge Journey
	PEO2b Is KM recognized as a key organizational competence?	KMAT
	PEO2c Employees are ready and willing to give advice or help on request from anyone else within the company	Knowledge Journey, KMCA
3	***PEO3a*** Is there any incentive system in place to encourage the knowledge sharing among employees? - Employee's KM contribution are taken into consideration - Rewards for team work, knowledge sharing/re-use	Knowledge Journey
	PEO3b Are the incentive systems attractive enough to promote the use of KM in the organization?	Self developed
	PEO3c Are the KM projects coordinated by the management?	Self developed
	PEO3d Are there individual KM roles that are defined and given appropriate degree of authority? - CKO - Knowledge Officers / Workers	Developed based on Siemens' KMMM Level 3, Infosys KMMM Level 3 Knowledge Journey
	PEO3e Is there a formal KM strategy in place?	Developed based on Siemens' KMMM Level 4
	PEO3f Is there a clear vision for KM?	Self developed
	PEO3g Are there any KM training programs or awareness campaigns? e.g. introductory/specific workshops for contributors, users, facilitators, champions	Developed based on Infosys' KMMM Level 3
4	***PEO4a*** Are there regular knowledge sharing sessions?	Developed based on Infosys' KMMM Level 4
	PEO4b Is KM incorporated into the overall organizational strategy?	Knowledge Journey
	PEO4c Is there a budget specially set aside for KM?	Knowledge Journey
	PEO4d Is there any form of benchmarking, measure, or assessment of the state of KM in the organization? - Balanced scorecard approach - Having key performance indicators in place - Knowledge ROI	KMAT - Knowledge Journey - Knowledge Journey - Developed based on Infosys' KMMM Level 5
5	***PEO5*** Has the KM initiatives resulted in a knowledge sharing culture?	Developed based on Infosys' KMMM Level 5

Table 9. Proposed G-KMMM Assessment Instrument (Continued)		
Level	**Question**	**Source**
KPA: Process		
2	***PRO2*** Is the knowledge that is indispensable for performing routine task documented?	Developed based on Infosys' KMMM Level 2
3	***PRO3a*** Does the KMS improve the quality and efficiency of work?	Self developed
	PRO3b Is the process for collecting and sharing information formalized? - Best practices and lessons learnt are documented	KMAT
4	***PRO4a*** Are the existing KM systems actively and effectively utilized?	Knowledge Journey
	PRO4b Are the knowledge processes measured quantitatively?	Developed based on Infosys' KMMM Level 4
5	***PRO5*** Can the existing KM processes be easily adapted to meet new business requirements?	Developed based on Siemens' KMMM Level 5
KPA: Technology		
2	***TEC2a*** Are there pilot projects that support KM?	Developed based on Siemens' KMMM Level
	TEC2b Is there any technology and infrastructure in place that supports KM? - E.g. Intranet portal - E.g. Environments supporting virtual teamwork	Developed based on Infosys' KMMM Level 3.
3	***TEC3*** Does the system support the business unit?	Developed based on Infosys' KMMM Level 3
4	***TEC4a*** Does the KMS support the entire organization?	Developed based on Infosys' KMMM Level 4
	TEC4b Is the KMS tightly integrated with the business processes?	Self developed
5	***TEC5*** Are the existing systems continually improved upon (e.g. continual investments)?	KPQM Level 5

3.4 Towards an Ideal KMMM

The proposed G-KMMM seeks to fulfill many requirements of an ideal KMMM. It is applicable to several objects of analysis, including the organization as a whole and individual organizational units. With a clear definition of key concepts and development of an accompanying assessment instrument, G-KMMM is comprehensible and allows systematic and structured assessment. Although the current assessment instrument is likely to generate more qualitative response, quantitative data can be collected when objective measures such as the number of document hits and usage statistics of KM systems are included. By identifying KPAs and specifying their characteristics, the G-KMMM also pinpoints important areas of focus and suggests the need to refer to proven management concepts (e.g., human resource planning, technology change management). In addition, it supports continuous learning and improvement by suggesting that KM should be “continually improved upon” (maturity level 5), even when organizations have attained a high level of maturity.

4. Research Design

To initially assess the applicability of the proposed G-KMMM, we studied a multi-unit IS organization's KM maturity. The case study methodology allows us to gather rich data and gain better understanding of the complex interactions among people, technologies, and units (Dubé and Paré, 2003) in KM development. Since our purpose was to study the utility of the G-KMMM in an actual context, we adopted the descriptive positivist approach, in which data collection and interpretation were guided by a pre-specified model (Orlikowski and Baroudi, 1991).

4.1 Case Background

The IS organization in our case, "Computer Hub", provides computing and IT infrastructure support for a large public university, which consists of over 30,000 students and more than 4,000 teaching, research, and administrative staff. The organization was a suitable context for our study because the nature of its work was knowledge-intensive and involved specialized expertise that must be carefully managed. It had also begun to explore various KM applications since 2002. In addition, the Computer Hub was made up of multiple units which is typical of many large organizations. This provided a unique opportunity for us to examine whether the G-KMMM is flexible enough to be applied in complex organizations of this form.

During the study, we focused on ten units of the Computer Hub: the academic unit (AU), corporate unit (CU), call center (CC), and seven faculty units which included Architecture (ARU), Arts and Social Sciences (ASU), Business (BSU), Computing (CMU), Dentistry (DTU), Engineering (ENU), and Scholars Program (SPU). Each of these units served a large number of users, ranging from 150 to 6,000 people. Other faculty units were excluded because they were very small (i.e., less than five employees) and the use of KM applications were minimal at the time of the study.

The main roles of the AU and CU included university-wide IT application development and maintenance. The AU was in charge of systems serving the student population (e.g., course registration system), while the CU was responsible for managing systems tailored to the corporate segment (e.g., student administration system).

In contrast, the CC provided frontline call center and walk-in technical support for the university community. It was also in charge of campus-wide programs such as staff PC upgrade and student laptop ownership plan. It also managed a university-wide content management system (CMS) and electronic document management system (EDMS).

The faculty units catered to the specific IT needs of their respective faculties. Such a distributed structure was necessary because each faculty had different IT requirements. For example, the DTU required sophisticated imaging technology, while the SPU focused more on providing user support on the use of administrative systems. In addition to utilizing the infrastructure and services provided by the Computer Hub, these faculty units also hosted their own servers and developed their own applications to cater to faculty-specific requirements.

4.2 Data Collection and Analysis

A total of twenty interviews (two per unit) were conducted with managers and employees of the AU, CU, CC, and faculty units over three months. An interview guide was developed based on the assessment instrument proposed in Table 9. Each interview lasted 30 to 90 minutes. Table 10 provides the descriptive statistics of the participating units. With the permission of the interviewees, all interviews were recorded and transcribed for further analysis. We also requested for related documents and demonstrations of various KM systems. To improve the validity of our data, we triangulated the data sources of information by verifying interviewees' accounts against one another. Secondary data was also gathered from relevant documents and websites. The results of our analysis also agree with that of a subsequent independent study that assessed and compared the KM capabilities of various units in the Computer Hub in terms of people (e.g., expertise), process (e.g., knowledge sharing, knowledge creation), and technological (e.g., investment in KM technology) factors using a different assessment instrument. This provides some indication that the proposed assessment instrument possesses concurrent validity.

Table 10. Descriptive Statistics of Faculty Information System Units

Faculty Unit	Faculty Strength		Faculty Unit Staff		Website[1]		Intranet[2]	
	Students	**Staff[3]**	**IT Professionals**	**Technicians / Others**	**Faculty**	**Unit**	**Faculty**	**Unit**
ARU	1500-2000	100-150	6	7	Y	Y	Y	Y
ASU	6000	500	8	3	Y	Y	Y	Y
BSU	1500	100	5	3	Y	N	Y	Y
CMU	3000	150-200	13	30	Y	Y	Y	Y
DTU	150	30-40	4	2	Y	Y	Y	N
ENU	5000-6000	300	15	8	Y	Y	Y	Y
SPU	800-1000	50-60	2	3	Y	N	Y	N

1. Website refers to a collection of interconnected web pages that are publicly accessible.
2. Intranet refers to a private network that is only accessible by users in the associated faculty or unit.
3. The figures include both academic and administrative staff.

Note: Y indicates that the unit has a website/intranet. N indicates otherwise.

Based on information collected during interviews and from secondary sources such as documents and websites, the KM maturity of each unit was assessed by evaluating whether or not a particular practice (described by an item in the assessment instrument in Table 9) was carried out. To qualify for a maturity level in a KPA, a unit must carry out all key practices of that level. For example, a unit that carried out the practices described in items PEO2a to PEO4a but not item PEO4b can be said to have attained maturity level 3 in people KPA, since it has not implemented all practices characterizing level 4.

5. Results

The findings for the AU, CU, and CC, which managed university-wide applications and catered to staff members and students in general, are first presented. This is followed by the results for faculty IT units, which focused on serving the needs of specific faculties. A cumulative assessment is then conducted for the Computer Hub as a whole based on these analyses. The resultant maturity levels of each unit are summarized in Table 11.

Table 11. Maturity Levels of IT Units								
Item	**AU, CU, CC**	**ARU**	**ASU**	**BSU**	**CMU**	**DTU**	**ENU**	**SPU**
People Maturity	***2***	***2***	***2***	***1***	***2***	***1***	***2***	***1***
PEO2a	Y	Y	Y	N	Y	N	Y	N
PEO2b	Y	Y	Y	N	Y	Y	Y	N
PEO2c	Y	Y	Y	Y	Y	Y	Y	Y
PEO3a	N	N	N	N	N	N	N	N
PEO3b	N	N	N	N	N	N	N	N
PEO3c	Y	Y	N	N	Y	N	N	N
PEO3d	N	N	N	N	N	N	N	N
PEO3e	N	N	N	N	N	N	N	N
PEO3f	Y	N	N	N	Y	N	N	N
PEO3g	Y	N	N	N	N	N	N	N
PEO4a	N	N	N	N	N	N	N	N
PEO4b	N	N	N	N	N	N	N	N
PEO4c	N	N	N	N	N	N	N	N
PEO4d	N	N	N	N	N	N	N	N
PEO5	N	N	N	N	N	N	N	N
Process Maturity	***3***	***2***	***2***	***1***	***3***	***1***	***2***	***1***
PRO2	Y	Y	Y	N	Y	N	Y	N
PRO3a	Y	N	N	N	Y	N	N	N
PRO3b	Y	N	N	N	Y	N	N	N
PRO4a	N	N	N	N	N	N	N	N
PRO4b	N	N	N	N	N	N	N	N
PRO5	N	N	N	N	N	N	N	N
Technology Maturity	***2***	***3***	***3***	***1***	***3***	***1***	***1***	***1***
TEC2a	Y	Y	Y	N	Y	N	Y	Y
TEC2b	Y	Y	Y	N	Y	N	N	N
TEC3	N	Y	Y	N	Y	N	N	N
TEC4a	N	N	N	N	Y	N	N	N
TEC4b	N	N	N	N	N	N	N	N
TEC5	N	N	N	N	N	N	N	N
Overall Unit Maturity	***2***	***2***	***2***	***1***	***2***	***1***	***1***	***1***
Note: Y indicates that the unit demonstrated the characteristic described by the item. N indicates otherwise.								

5.1 Academic (AU), Corporate (CU), and Call Center (CC) Units

In relation to the *people* KPA, AU, CU, and CC recognized knowledge as a critical resource that must be competently managed. Every few months, sharing sessions were held to facilitate knowledge transfer among staff members. Staff members were aware of the benefits of knowledge sharing and were generally willing to advice or help their colleagues. The management also articulated a clear KM vision and conducted KM training workshops. However, since there was a lack of incentive systems to encourage staff members to participate in KM activities (PEO3a), it was concluded that the units were at maturity level 2 for the people KPA (see Table 11).

Pertaining to the *process* KPA, the units had some processes for capturing, sharing, and reusing routine documents and knowledge and specific KM technologies were used to support these processes formally. For example, project portals were set up with Microsoft SharePoint to facilitate collaboration and knowledge sharing among application development project team members. A Developer's Corner was also set up to encourage knowledge sharing among system developers. Content on the Developer's Corner included system procedures, guidelines, links to programming websites, and articles on SAP system interfaces. However, the use of these KM systems was still lower than expected (PRO4a) at the time of study as users lacked motivation to adopt them. This suggested that the units were at maturity level 3 for the process KPA.

With respect to the *technology* KPA, other than EDMS, CMS, Microsoft SharePoint, and Developer's Corner, an IS for tracking the inventory of software developed was also implemented. This system served as a basis for encouraging component reuse across projects in different IT units and had gained acceptance quickly. At the time of data collection, it had over 80 registered applications. Overall, although AU, CU, and CC had implemented several KM systems to support various KM activities, these systems contained mainly technical information and offered little support to administrative staff members and managers (TEC3). Considering this, the units were deemed to be at maturity level 2 for the technology KPA.

In summary, the AU, CU, and CC were at maturity level 2 for the people and technology KPAs, since they were aware of the need to formally manage their knowledge resources and had initiated several pilot KM projects. They were at level 3 for the process KPA since processes for content and information management were formalized. At the unit level, it was thus concluded that they were at KM maturity level 2 since they had not achieved maturity level 3 for the people and technology KPAs.

5.2 Faculty IT Unit

5.2.1 People KPA

It was observed that the BSU, DTU, and SPU were at maturity level 1 for the people KPA. In the BSU and SPU, although employees were generally willing to share knowledge, knowledge was not yet recognized as essential and they were mostly unaware of the need for formal KM (PEO2a). Hence, they were considered to be at maturity level 1.

In DTU, as all staff members worked in the same office, direct face-to-face communication was preferred to computerized collaboration tools. Although knowledge was considered as a key organizational competence and employees were willing to share knowledge, KM was not yet recognized as essential to the long-term success of the unit (PEO2b).

In contrast, the ARU, ASU, CMU, and ENU had achieved maturity level 2 for the people KPA. In all four units, employees possessed strong technical skills and had worked on both faculty and campus-wide projects. For example, ASU contributed the largest percentage of its staff to campus-wide projects among all the faculty units. Around 30% of its employees were involved in campus-wide projects such as the development of class registration system and timetable system. They often shared their experiences with one another as well as with other faculties. In the ENU, although there was no formal incentive for sharing knowledge, employees were generally willing to participate in KM activities as they believed it would affect their performance evaluation.

In addition, the management of the ARU and CMU was active in coordinating and supporting KM initiatives and this had motivated employees to participate actively in KM activities such as sharing knowledge with one another (PEO3c). In the CMU, which was described as a "mini Computer Hub" by other units due to its wide array of services offered, the management also articulated a clear KM vision to guide the adoption and development of KM (PEO3f).

5.2.2 Process KPA

The BSU, DTU, and SPU were at maturity level 1 for the process KPA. In the DTU and SPU, there was no formal repository of knowledge and knowledge was mainly shared informally through face-to-face interactions (PRO2). Although the BSU made use of the EDMS provided by the Computer Hub to store routine documents, there was no formal process for updating the content regularly and employees preferred to consult their colleagues face-to-face when they needed help since they were located in the same office.

On the other hand, the ARU, ASU, and ENU were at maturity level 2. All three units had several processes for documenting and sharing routine knowledge (PRO2). For example, the ARU stored policies, guidelines, and standard operating procedures for supporting application development and examination mark processing. Recognizing the need to manage information requests from users, the unit was also exploring the potential of business intelligence applications. In the ENU, knowledge about routine tasks was regularly documented on its versioning applications and file directories. On top of documentation, the ASU also held knowledge sharing sessions when necessary to facilitate knowledge transfer among employees. However, these sessions were kept informal and face-to-face because the unit was small and employees found it easier to share ideas directly.

The CMU was relatively more advanced in terms of the process KPA, being the only faculty IT unit attaining maturity level 3. The unit had several formal processes for collecting and sharing knowledge about routine tasks (PRO3b). For example, staff members were required to regularly update the knowledge stored on the unit's web portal. The portal served as a knowledge base of lessons-learned which contained networking guides, frequently asked questions, and troubleshooting tips that were shared among helpdesk and workshop staff members. These knowledge helped to improved their efficiency and effectiveness in addressing user requests (PRO3a).

5.2.3 Technology KPA

The BSU, DTU, ENU, and SPU were at maturity level 1 for the technology KPA. In the BSU and ENU, there was little effort to explore the use of KM. Although the EDMS was adopted, it was mainly used for storing documents rather than sharing knowledge. While the ENU had made initial attempts to introduce knowledge sharing systems, the pilot project was eventually abandoned because face-to-face communication was generally preferred among staff. In the DTU, the focus was mainly on supporting imaging technology and medical equipment. Limited manpower had compelled the unit to attend to its main responsibilities rather than exploring KM applications or systems. At the time of study, the SPU was piloting a forum that could be used as a knowledge sharing platform (TEC2a). It was expected that the forum would be able to support KM in the unit effectively as it developed further.

The KM technology in the ARU, ASU, and CMU were more mature at level 3. The ARU and ASU utilized EDMS and common directory services provided by Computer Hub to share their files and documents. In addition, the ARU also maintained a faculty web portal to support users' job tasks (TEC2b). In general, the unit preferred using existing software as it had limited manpower for developing its own application. In the ASU, an intranet that contained procedures and policies that supported the unit's work was implemented. The unit had also planned to develop a central repository for sharing technical code and information. However, the plan was put on hold due to manpower constraints. In the CMU, UNIX server, and helpdesk service website were implemented to provide knowledge support to the unit's work. On the UNIX server, directories were used to store system configuration documents and meeting minutes. These were generally plain-text documents that were searchable using native UNIX commands (e.g., grep). The helpdesk service website facilitated knowledge transfer between the unit and users by providing comprehensive user guides. On top of these, the CMU was also experimenting with an open source collaborative portal that featured forums, mailing lists, and source code management to further support knowledge sharing during application development projects.

5.3 Computer Hub

To determine the KM maturity of the Computer Hub as a whole, the distribution of individual unit's maturity rating was analyzed (see Table 11). For the Computer Hub to achieve a certain maturity level, all its units must achieve positive ratings for all items characterizing the level. In other words, the maturity level of the least mature IT unit will determine the maturity level for Computer Hub.

With regard to the *people* KPA, it was observed that seven out of ten units had achieved maturity level 2. The remaining units had less recognition for the importance of formal KM in their long-term success and were considered to be at level 1. Hence, the Computer Hub's people KPA was at level 1. However, even in less matured units, staff members were generally willing to share their expertise with one another. Hence, the potential for these units to improve their people KPA was fairly high. It was also observed that although none of the units offered formal incentives to encourage participation in KM activities, some informal incentives were in place. For example, the ENU's manager noted that better appraisal was likely for staff members who participated in KM activities.

In terms of the *process* KPA, two units were still at level 1 as documentation of knowledge critical to the performance of routine tasks was not yet guided by any formal process. Hence, the Computer Hub's overall process KPA was still at level 1. To improve its rating, Computer Hub could encourage other units to share their experience with the less advanced units to help them establish suitable KM processes that could address their specific needs.

Regarding the *technology* KPA, four out of ten units were at maturity level 1. Therefore, the Computer Hub's overall technology KPA was also at level 1. The four units were lacking in infrastructure that could adequately support KM activities. Although systems such as the CMS and EDMS were provided by the Computer Hub, these units had not exploited the systems fully to address their KM needs. One possible reason for this was that staff members of these units were collocated and it was therefore more convenient and natural to share knowledge face-to-face. Another reason was that the lack of human resources prevented them from exploring and experimenting with the potential of KM systems.

Overall, it was observed that the KM maturity of the Computer Hub was still at level 1. However, noting that many units were already at level 2 for the three KPAs and some had even reached level 3, it appeared that the organization was closing in on level 2.

6. Discussion and Conclusion

The G-KMMM identifies salient aspects of KM development that allow organizations to grasp the essential elements of the phenomenon. Its applicability in assessing KM development and indicating possible future improvements was demonstrated in an exploratory case study. In particular, a unit found to be at one maturity level seldom implements practices characterizing higher maturity levels. Apart from the few exceptional cases (e.g., ARU's people KPA is at maturity level 2 but it implemented practices characterizing level 3), such occurrence was not observed in other units. This suggests that the proposed model possesses some degree of convergent validity and seems to realistically capture the development of KM in the case organization. It is also flexible enough to be applied to many levels of aggregation, including units, departments, and the organization as a whole. In addition, it is independent of the type of KM system and can be applied to personalization as well as codification-based KM strategies.

It is important to clarify that the G-KMMM does not consider all organizational units to be equally appropriate for assessment of KM maturity. Rather, focus should be on knowledge-intensive units (e.g., research and development) where effective KM is critical since the manifestations and effectiveness of KM are likely to be most clearly discerned in these units.

As shown in the case study, different units of an organization may be at different maturity levels for different KPAs. For example, the CMU was at maturity level 2 for the people KPA but its process and technology KPA were found to be at level 3. Other units such as the AU, CU, CC, ARU, ASU, and ENU also had different maturity ratings for different KPAs. This suggests that the three KPAs are distinct and unlikely to be correlated with one other, providing preliminary evidence for discriminant validity. This also demonstrates the model's usefulness as a diagnostic tool that is able to pinpoint areas needing further improvement. It also allows the assessment outcome to be reported at different levels of abstraction as the ratings for different units can be aggregated into a single rating for the organization as a whole.

It is also important to note that although the G-KMMM defined the fifth maturity level to be the most advanced level, it does not suggest that organizations at this level will cease developing their KM competence. Rather, as KM concepts and technologies evolve, the conditions for attaining maturity are likely to change and serve more like moving targets to encourage continuous learning and improvement rather than a definite end by themselves.

The case study has highlighted a few areas for future investigation. An avenue for future research will be to investigate the relative importance of practices in each KPA at different stages of maturity. Identifying and understanding these dynamics may help organizations in charting their KM development better. In addition to people, process, and technology aspects, it may also be important to consider situational factors in the development of KM. For example, in the case study, the manager of CC highlighted that a major roadblock hindering users' adoption of documentation systems was that local legal jurisdiction did not recognize the legality of electronically-filed documents unless their process flow was certified by an established accounting firm. As the certification process was tedious and costly, the university found it more economical to stick to paper documents and use of the EDMS was often seen as nonessential. This suggests that future refinements of the proposed model may need to consider environmental conditions outside the control of the organizations.

To assess its generalizability, future research can apply the G-KMMM to different contexts. More quantitative data in the form of summarized statistics can also be collected from a larger sample of organizations by developing survey questionnaire based on the proposed instrument and using finer measurement scales such as Likert scales. This could facilitate the comparison of KM development patterns across organizations and allow a more thorough assessment of the validity of the proposed model.

While the underlying objective of the proposed model is to improve KM development in organizations and eventually enhance organizational performance, the current model focuses on identifying the key aspects of KM development and assessing the level of KM maturity and does not explicitly hypothesize or predict any relationship between maturity level and organizational performance. Although studies related to CMM have provided empirical evidence that organizations progressing along the pathway of CMM witnessed improved performance (e.g., Herbsleb et al., 1997; Lawlis et al., 1995; Lucas and Sutton, 1977), there is a lack of studies verifying such effects for KMMMs and IS stage models (Benbasat et al., 1984). To assess the predictive validity of KM maturity on organizational performance, large-scale studies examining the maturity and organizational performance of organizations in various industries are needed.

The proposed G-KMMM recognizes that KM is unlikely to be achieved in one giant leap. Its staged structure provides a general understanding of the gradual and holistic development of KM. It is hoped that the G-KMMM can serve as both an effective diagnostic tool for assessing KM efforts and a coherent roadmap that guides academic and practical KM endeavors.

References

Alavi, M. & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. MIS Quarterly, 25(1), 107-136.

American Productivity and Quality Center (APQC) & Arthur Andersen (1996). The knowledge management assessment tool (KMAT) (http://www.kwork.org/White_Papers/KMAT_BOK_DOC.pdf)

AMR Research (2007). The knowledge management spending report 2007-2008. (http://www.amrresearch.com/Content/View.asp?pmillid=20744)

Apostolou, D., Mentzas, G., & Abecker, A. (2008-2009). Managing knowledge at multiple organizational levels using faceted ontologies. The Journal of Computer Information Systems, 49(2), 32-49.

Armour, P. G. (2000). The case for a new business model: Is software a product or a medium? Communications of the ACM, 43(8), 19-22.

Benbasat, I., Dexter, A. S., Drury, D. H., & Goldstein, R. C. (1984). A critique of the stage hypothesis: Theory and empirical evidence. Communications of the ACM, 27(5), 476-485.

Bukowitz, W. & Williams, R., (2000). Knowledge pool. CIO Magazine, July.

de Jager, M. (1999). The KMAT: Benchmarking knowledge management. Library Management, 20(7), 367-372.

Dubé, L. & Paré, G. (2003). Rigor in information systems positivist case research: Current practices, trends, and recommendations. MIS Quarterly, 27(4), 597-635.

Ehms, K. & Langen, M. (2002). Holistic development of knowledge management with KMMM

(http://www.knowledgeboard.com/doclibrary/knowledgeboard/kmmm_article_siemens_2002.pdf)

Gottschalk, P. & Khandelwal, V. K. (2004). Stages of growth for knowledge management technology in law firms. Journal of Computer Information Systems, 44(4), 111-124.

Grover, V. & Davenport, T.H. (2001). General perspectives on knowledge management: Fostering a research agenda. Journal of Management Information Systems, 18(1), 5-21.

Handzic, M., Lagumdzija, A., & Celjo, A. (2008). Auditing knowledge management practices: model and application. Knowledge Management Research & Practice, 6(1), 90-99.

Henderson, J.C. & Treacy, M. (1986). Managing end-user computing for competitive advantage. Sloan Management Review, 27(2), 3-14.

Herbsleb, J., Zubrow, D., Goldensen, D., Hayes, W. & Paulk, M. (1997). Software quality and the capability maturity model. Communications of the ACM, 40(6), 30-40.

Holland, C. P. & Light, B. (2001). A stage maturity model for enterprise resource planning systems use. The DATA BASE for Advances in Information Systems, 32(Spring), 34-45.

Huber, G. P. (1991). Organizational learning: The contributing processes and the literature. Organization Science, 2(1), 88-115.

Huff, S. L., Munro, M. C., & Martin, B. H. (1988). Growth stages of end-user computing. Communications of the ACM, 31(5), 542-550.

INPUT (2005). Federal knowledge management market view report. (http://www.input.com/corp/press/detail.cfm?news=1091)

Kazanjian, R. K. & Drazin, R. (1989). An empirical test of stage of growth progression model. Management Science, 35(12), 1489-1503.

King, J. L. & Kraemer, K. L. (1984). Evolution and organizational information systems: An assessment of Nolan's stage model. Communications of the ACM, 27(5), 466-475.

Klaus, H. & Gable, G. (2000). Senior managers' understandings of knowledge management in the context of enterprise systems. Proceedings of the 2000 Americas Conference on Information Systems, Association for Information Systems, 981-987.

Klimko, G. (2001). Knowledge management and maturity models: Building common understanding. Proceedings of the 2nd European Conference on Knowledge Management, 2001.

KPMG Consulting (2000). Knowledge management research report. (http://www.insite.cz/data/kpmg_km_report2000.pdf).

Kulkarni, U. & Freeze, R. (2004). Development and validation of a knowledge management capability assessment model. Proceedings of the 25th International Conference on Information System, 657-670.

Kulkarni, U. & St. Louis, R. (2003). Organizational self assessment of knowledge management maturity. Proceedings of the 9th Americas Conference on Information Systems, 2542-2551.

Lawlis, P., Flowe, R., & Thordahl, J. (1995). A correlational study of the CMM and software development performance. Software Process Newsletter, IEEE Technical Council on Software Engineering, 7, 1-5.

Lee, J. & Kim, Y. (2001). A stage model of organizational knowledge management: a latent content analysis. Expert Systems with Applications, 20(4), 299-311.

Lucas, H. C. & Sutton, J. A. (1977). The stage hypothesis and the s-curve: Some contradictory evidence. Communications of ACM, 20(4), 254-259.

Magal, S. R. (1989). The evolution of information centers: A stage hypothesis. DATA BASE, 20(1), 39-46.

McGarry, F., Burke, S., & Decker, B. (1998). Measuring the impacts individual process maturity attributes have on software projects. Proceedings of the 5th International Software Metrics Symposium, 52-60.

Mohanty, S. K. & Chand, M. (2004). 5iKM3 knowledge management maturity model for assessing and harnessing the organizational ability to manage knowledge. TATA Consultancy Services, 2004 (http://www.tcs.com/NAndI/default1.aspx?Cat_Id=7&DocType=324&docid=419)

Nolan, R. (1979). Managing the crisis in data processing. Harvard Business Review, 57(2), 115-126.

Orlikowski, W. J. & Baroudi, J. J. (1991). Studying IT in organizations: Research approaches and assumptions. Information Systems Research, 2(1), 1-28.

Paulzen, O. & Perc, P. (2002). A maturity model for quality improvement in knowledge management. Proceedings of the 13th Australasian Conference on Information Systems, 243-253.

Pillai, S., Gupta, R. K., & Saxena, K. B. C. (2008). From rhetoric to reality: an enquiry into KM initiatives in an organisation of higher learning. Journal of Information & Knowledge Management, 7(3), 135-143

Powers, V. J. (1999). Xerox creates a knowledge sharing culture through grassroots efforts. Knowledge Management in Practice, APQC. (http://www.socialeconomy.info/en/node/1342)

Van de Ven, A. H. & Poole, M. S. (1995). Explaining development and change in organizations. Academy of Management Review, 20(3), 510-540.

Weerdmeester, R., Pocaterra, C., & Hefke, M. (2003). VISION: Next generation knowledge management: Knowledge management maturity model. Information Societies Technology Programme.

WisdomSource (2004). Knowledge management maturity (K3M). WisdomSource News, 2(1) (http://www.wisdomsource.com/wisdomsourcenews-20040531.html)

Wong, K.Y. & Aspinwall, E. (2004). Knowledge management implementation frameworks: a review. Knowledge and Process Management, 11(2), 93-104.