ISSN: 2167-1508
v12 n5210

Knowledge Management System Development Approaches: Evolution or Stagnation?

William H. Money
wmoney@citadel.edu
School of Business
The Citadel
Charleston, SC 29409, USA

Lionel Mew
lmew@richmond.edu
Information Systems
University of Richmond
Richmond, VA 23173, USA

Abstract

This paper investigates evolution of Knowledge Management (KM) systems development approaches. KM has been an important topic for over forty years. Period KM systems development has been based on definitions of knowledge that have evolved, with systems developed using tools and approaches characteristic of the time. The first KMS were gateways to static information supporting integrative business processes. As KM evolved, knowledge became seen as dynamic, moving within the enterprise due to organizational processes. Current thought focuses on tacit knowledge, which is hard to explicitly transfer, making KM a social process. The question is whether development approaches have kept up with evolving definitions of knowledge. This paper identifies approaches implementing new KM systems, draws on the literature to examine how they are used, and discusses whether they reflect knowledge's changing nature. The methodologies used to develop KM systems are examined with the goal of providing insight into approaches that work.

Keywords: Knowledge Management, System Development, Paradigm Shift

1. INTRODUCTION

This paper discusses how KMS development methodologies have changed, but not necessarily kept up with changing (expanding) definitions of knowledge. As our concept of knowledge has broadened from a static content model to a more dynamic model followed by social content paradigms (Tzortzaki & Mihiotis, 2014), a review of the research suggests that there has been some change in the way KMS are constructed. However, a question is whether KM system development methodologies have evolved purposefully as our understanding of knowledge has expanded, or by responding simply to development advances and not in response to knowledge paradigm shifts.

We do not delve deeply into the conceptualization of knowledge and its history in this paper. It is well recognized, since the 17th century philosophers (led by Descartes' work) have approached knowledge as involving human acceptance of facts and an understanding that something is not in doubt, or has some large degree of certainty. If the certainty is extremely high, it is then knowledge, accredited as certain, and not doubted (Newman, 2008).

Researchers also broadly agree that information and knowledge are closely linked, with information being accepted as categorized, or meaningfully arranged data. Knowledge, according to Denning (1998), is an extension of this data – the understanding of information, for after information becomes certain, we have knowledge. Knowledge exists for humans where something (a question or understanding) is believed to be true or certain (Denning, 1998).

Information systems are characterized that are designed and developed to manage organizational knowledge as Knowledge Management Systems (KMS). These KMS may functionally aid organizational learning, ingest and store organizational knowledge, and make it accessible as required for recall and application (Damodaran & Olphert, 2000). The content of a KMS may include corporate history, project and personnel experience and expertise, and the knowledge that promoted the success of the business.

In the late 1980's, understanding of knowledge was advanced with the conceptualization of a knowledge hierarchy by Ackoff (1989) where data led to information, knowledge, and finally wisdom in a hierarchy depicted as a DIKW pyramid. The model has been discussed, with definitions argued and examined in numerous papers (for example see (Frické, 2009; Hey, 2004; Sharma, 2008; Tuomi, 1999). However, until the 2009 time period, the discussion and papers did not begin to deeply analyze or propose succinct step-like or phases for processes that would be used to describe how a KMS could be constructed, and the systematic function a KMS would perform.

Jennex (2009) dissected and discussed the pyramid to clarify the definitions used and offered insight and design inputs and outputs to advance KMS construction. He identified the processing sequence differences (upward form Ackoff's pyramid design) and downward (from Tuomi's) available; postulated and gave clear use case examples showing that a revised knowledge pyramid could have bi-directional flows; validation mechanisms (for KM strategy); incorporating social networks (data creation and transport); filtering; communication; collaboration and work processing elements. Jennex points out how KMS are functionally more than just knowledge storage and retrieval technologies.

Although metrics tend to vary, it is widely accepted that KMS performance measurement revolves around how effective the systems are in terms of meeting organizational goals, while enhancing individual performance and satisfaction. The long history of knowledge studies has a practical significance for organizational work because it greatly impacts the ability of people and organizations to understand and act effectively. Organizations must survive in competitive environments, and assemble knowledge to support organizational processes, promote effective functioning and provide valuable assets for sale or exchange. As both knowledge and competitors improve, KMS practices and support must also improve. They must recognize the developments in technology and people-centric areas to continue success (Wiig, 2000).

The approaches and activities for capturing and managing knowledge have been undertaken frequently as practical projects targeted at providing direct support for organizational objectives with a clear understanding of underlying organizational processes that are implemented with or directly supported by the relevant KMS. These KM projects are not an attempt to construct organization wide KMS for they focus KM efforts directly on organizational needs and capabilities by constructing so-called adaptive, contextual, comprehensive, and people-centric types of environments that focus on knowledge-related concerns (Wiig, 2000).

These approaches have resulted in initiatives to increase knowledge sharing among individuals by building instructional and learning programs and knowledge distribution capabilities; manage knowledge through capturing, manipulating, and locating knowledge; and on knowledge utilization by building and exploiting information management to improve enterprise economic value. Finally, some have developed into more widely used tools where information and knowledge is more broadly utilized and exploited as a central resource. These KMS function as created environments which focus constant, widespread organizational attention on ensuring competitive information is available to sustain long-term success and viability (Wiig, 2000). Efforts have thus been directed at turning tacit knowledge into explicit knowledge with the straightforward capture and sharing methods.

As the definition and use of knowledge has expanded from static to dynamic to social, research shows that the tools used to develop KMS have changed, but not necessarily in concert with our expansion of the new definitions associated with the knowledge pyramid, or a design based on an understanding of the many different function, and objects of a KMS. Little research is available discussing how knowledge is used in organizations, how knowledge supports organizational goals, and that the use cases for knowledge that would be required to develop robust KMS are not readily available or well validated. It is suggested that a deeper understanding of how people interact with knowledge must be gained, and that methodologies for developing KMS be updated to reflect that understanding.

2. WHAT IS KNOWLEDGE?

The definitions and theories of knowledge are continuously evolving. These changes in the understanding of knowledge are in turn modifying and adding to what is incorporated into the KMS, and how the KMS must be constructed and managed as they grow. For the previous 20 years or more, Davenport, De Long, & Beers' 1998 description of how experience, context, interpretation, and reflection become knowledge when united with information has been a dominant theme. The resulting KMS products have been important for both decisions and actions. Unfortunately, differentiating between the information and knowledge is both difficult and problematic in practice, but it is apparent that human input is important as data becomes information and information then becomes knowledge (Davenport, De Long, & Beers (1998).

How Content affects the KMS

KMS based on this conceptualization of knowledge are constructed and used for a basic purpose that has become increasing complex. They are designed to collect, hold, and when called upon (by humans or decision tools) – deliver knowledge to users. These focused knowledge management functions are valuable because they leverage the inputs (data), support analysis, may also contain experience, and individual knowledge inside and outside of an organization (Ruggles, 1998). As the types of data included in the systems has expanded to include Big Data with unstructured text, sensor outputs, and social media. In 2013, Jennex & Bartczak conceptualized a revised knowledge pyramid to describe the knowledge that may be included in KMS of today. These authors postulate that the actions of modern systems incorporate learning, filtering, and transformation processes to generate a significant difference between the KM knowledge pyramid and the earlier general knowledge pyramid (Jennex & Bartczak, 2013).

The 2013 Jennex a& Bartczak pyramid describes the actions through which a KM delivers actionable intelligence and identified filters, functional processes, and technologies as being integral to the delivery process. However, the authors note that KM, as comprehended and depicted through a knowledge pyramid, does not incorporate Big Data, analytics, and the Internet of Things. In a more recent 2017 paper, Jennex recognizes how understanding of the data has expanded and utilized this KM conceptualization to further evolve the KM pyramid.

The knowledge sought and potentially included in the KMS discussed in this paper use the Jennex definition and postulate that a KMS must address traditional model elements and new ones identified and discussed by Jennex & Bartczak in 2013. The KMS of today must address vast amounts of data, a huge variety of content to generate value from data collected from many combined sources.

The Content Approach

The content of knowledge that must be stored in systems also has to be analyzed and may be described in terms of four core technological competencies that can deliver a competitive advantage to an organization. The content, as suggested by Leonard-Barton, includes skill and knowledge bases, physical technical systems, managerial systems, and values and norms of the organization (Barton, 1995).

In analyzing the content, some inroads have been made into the systems, but not in how they are to be constructed. For example, knowledge methods applied to the transport process that might move knowledge from one place to another within organizations have been categorized. Barton (1995) further suggests these methods include a recognized technical transfer capability (to a site) utilizing four approaches (assembly or turnkey, adaptation and localization, system, redesign, product design).

However, this development approach assumes the use of methodologies and tools that are not those employed in the information systems (much less KMS) of today, and further fails to suggest how the expanding data in the knowledge pyramid is to be captured and shared.

Enterprise Integration and Collaboration

Organizations that must later combine and share knowledge have followed the development trends of the day. The growth of database, data marts and data warehouses has driven this KMS effort to build enterprise KMS.

3. ISSUES IN IMPLEMENTING KM SYSTEMS

Quaddus & Xu (2005) point out the many concerns with KMS when they note that the long history of knowledge and knowledge management is over 4000 years old. They employed key personnel interviews and content analysis to identify factors and variables that impact KMS adoption and diffusion. The four major variables they identified affecting KMS adoption and diffusion were: organizational culture, top management support, benefits to individuals, and a dream of a KMS. However, they did not identify how the systems were developed or acquired or the issues involved in the broader acquisition process. According to Quaddus & Xu (1995) these acquisition issues, as well as the changing nature of information and the ways individuals and organizations adopt, use and defuse information with KMS introduce additional issues that impact the development process. Unfortunately, Quaddus & Xu's work stops short of discussing how these issues affect the development process.

4. KM DEVELOPMENT THEN AND NOW

Research shows that first generation knowledge management tools are based on knowledge being defined as explicit, with information portals leading to information supporting business processes. In second generation systems, Tzortzaki & Mihiotis, note that knowledge becomes dynamic as it constantly moves within the organization using four processes: socialization, externalization, combination and internalization. They further suggest that a third generation of KM systems is based on an emerging definition of knowledge as heuristic, or tacit, which requires the use and diffusion of this knowledge to be based on social processes (Tzortzaki & Mihiotis, 2014).

The traditional development approaches generally offered for information systems (but not explicitly called for in KMS development) is to match information systems with the organizational tasks to be supported or automated, thus ensuring usage and directly tying systems to organizational benefits and a ROI (Kankanhalli, Tan & Wei, 2005a, 2005b). The theory of task/technology fit (TTF) (Goodhue & Thompson, 1995) is a frequently followed approach that postulates that the use of technology is governed by establishing a match of equivalent fit between technology features and the demands of the user's task. It is founded upon the arguments that experienced users will rationally select tools and activities is they can accomplish their work with the greatest net benefit. A variety of technology utilization and adoption studies have been used to support this theory in various functional areas including accounting system adoption (Benford & Hunton, 2000), broad workplace use (Dishaw & Strong, 1999), online consumer shopping (Klopping & McKinney, 2004), and knowledge search repository usage for knowledge seeking (Kankanhalli, Tan & Wei, 2005a).

The methodology to build a KMS is described some 15 years ago by Tiwana, who sought to provide a methodology and instructional guide for constructing an enterprise KMS. This work describes hands-on techniques and tools for making a KMS, using existing intranets, data warehouses, and current project management approaches. A 10-step plan provides checklists to locate and audit the tacit knowledge you already have and maximize ROI from a KMS. It also identifies some of the limiting factors such as excessive formalization and overreliance on technology, and supporting master prototyping, and staffing with a Chief Knowledge Officer (Tiwana, 2004). However, the limitations previously noted do not go quite far enough in explaining why KMS are difficulty to construct. They do not explain the limiting and restrictive role of roles of technology in the development processes.

There are five reasons that logically suggest why LMSs are so difficult to develop. First, they are not true KMS, but are smaller, with targeted data and information sharing tools. Second, these tools are built to deliver decision related information (that may become knowledge) to distinct populations. They are therefore owned and supported by user communities, and not entire enterprises with strategic objectives in mind. Third, sharing methodologies and viewing mechanisms are designed for the targeted users – not broad populations. Fourth, platforms, servers, and database technologies are limited in extensibility and flexibility. Once systems are constructed, they are difficult to expand and enhance for these perspectives. Politically, they are owned, financially the costs are large to redesign, and finally, the technology underlying the systems may not easily be expanded. The organization may have multiple identity management systems that cannot be readily integrated to permit wide distribution of the data, information and knowledge. Finally, the systems are not designed for sharing – from two perspectives. The systems in today's world are subject to significant security risks and threats. Attacks come in many forms and may be

ISSN: 2167-1508
v12 n5210

internally and externally generated. This has prompted systems developed by offices or departments, and even those in large enterprises to protect the KMS investment with firewalls that prohibit most other organization members from accessing the KMS or even exploring the data resident there. It is a world of protectionism – with the many firewalls designed and maintained by disparate groups who are focused most clearly on protection, and not strategic sharing.

Today there are new techniques. The development processes today follow a Devops process that packages all the required software and delivers any number of advantages to the developer and supporting organization. Under this paradigm, containers incorporate all the files, configuration and environmental variables, and software needed to execute any application. The containers share resources, but do not need a complete operating system to run the applications. The container executes the image through an engine that deploys these images on hosts.

The technology is not necessarily new, and can use an open source engine and universal runtime. Competitors exist that perform similar functions, including some that use a separate engine relying on an open, standard container format. This technology utilizes micro services and distributed applications, and efficiently requires only limited resources from a host, since the containers operate independently.

Overall, the approach encourages flexibility and lets the developer design and implement non-standard images with new application libraries, because the developer only has to make changes to the code in the container image, and then can redeploy that image for a user. The high degree of flexibility can be understood because this technology is not the same as virtualization, where an operating system and application are permitted to only access the underlying hardware and resources through a hypervisor layer separating memory, compute and storage and the operating system and application and services.

Under this design and tool, applications run on their own version of an OS, and other applications on the same host may use different OS versions. Containers inside of virtual machines may have multiple OSes that are safe spaces for execution without interfering with other applications using the same OS (Tech Target, 2017).

With containerization there are gains in efficiency for memory, CPU and storage compared to traditional virtualization and physical application hosting, because there can be many more application containers on the same infrastructure. Application containers can run on any system, making them highly portable. Reproducibility is also high because the file systems, binaries and other information stay the same through the build, test and production cycle. Since version control is at the image level, configuration management is simplified. Scanners and monitoring tools are needed since containers are not isolated from the OS and security threats have easier access to the entire system. An organization must create policies to manage privilege levels for containers for security (Tech Target, 2017).

Given containerization, one can readily see the advantages for systems KMS that are facing the previously listed issues and deficiencies. First, flexibility, second, no need to rewrite, and third, improved logical access. Essentially, deploy your legacy systems, and develop a logical integration plan. Sharing can be cone with new applications and services (Tech Target, 2017).

The big change after the use of containers is that the KMS of the future can run in the cloud. The world today has moved to the cloud/ this move has greatly expanded and enable data sharing, and use of information systems. The cloud delivers well discussed benefits in terms of expandability, added storage, etc., but knowing the limits of KMS How does the cloud treat firewalls?

The essential concern with applying our understanding to the cloud and firewalls is to appreciate what firewalls do to protect an organization's network and users, and infrastructure and servers. Most organizations and users are familiar with firewalls stand-alone products or services designed to protect an enterprise network and its users. Firewall application may also act virtually to protect traffic going to, from, and between applications (in the cloud). They are not installed to protect a perimeter but to manage access inside public or private clouds and between/among applications.

Control is maintained through dashboards and management consoles that display activity and perhaps lets those select options permitting displays of information, blockings, etc. This can be extended to remote access users, connected via tunnels or VPNs. (Organizations may find savings in extra and unneeded firewall services, tools, as well as savings in OS licensing, and hardware using combinations of cloud and containerizations technologies. With this process, new zero-day threats or fixes, can be changed instantly. Thus avoiding need to download and install updates (Zeichick, 2017).

As an example, Microsoft's hybrid connectivity offers both Internet and network connectivity. This is effectively an extension of a tiered infrastructure via virtual networks (Ormond, Dial & Martin, 2017). Amazon's AWS approach is a similar security management service for rule configuration and management across your accounts and applications. Compliance is maintained with a common set of security enforced at the enterprise level in a consistent, hierarchical manner. It permits one to launch resources into a virtual self-defined network resembling a traditional datacenter network (Barr, 2018).

Understanding what cloud and containerization do for the enterprise KMS is essential. Understanding these technologies can lead to new uses of the old (smaller and targeted) KMS already in existence. Legacy applications need not be rewritten, lowering the costs. And importantly – the firewalls are not used for protection. In the cloud containerization environment, the networks are virtual and can be defined.

This suggests a strategy of planning, migration and integration that is supported by the evolving understanding of the knowledge pyramid. Not only does this synergy between knowledge and how it is used redefine KMS development methodologies, but continuing technology emergence further change the paradigms under which the applications are designed. For example, as previously mentioned, the emerging cloud environments not only provide an easy place to put legacy applications, they are actually changing the way that development is conducted. Previous constraints such as data storage, application size, and performance are no longer relevant due to continued streamlining of development and operational processes due to cloud technologies. As the knowledge pyramid and information system development capabilities continue to evolve, the need to continue migrating, integrating and understanding must continue apace.

5. KNOWLEDGE PROJECT IMPLEMENTATION

As far back as 1998, Davenport, De Long, & Beers provided a different approach to the development issue in their study of practical knowledge management development by studying thirty-one knowledge management projects in twenty-four companies. They saw these projects as attempting to use knowledge to support and meet organizational objectives. They recognized that the term *knowledge* may be difficult to apply in some of the projects studied, but that many have a limited impact. The project characteristics included all being unfinished, but having specific business and knowledge management objectives. The projects addressed knowledge, as opposed to information or data, and four broad types of knowledge objective (with one usually being primary): (1) creating repositories, (2) improving access, (3) enhancing the environment, and (4) managing the knowledge asset (Gandomi & Haider, 2015).

The analysis of these 4 types of knowledge projects is informative because it begins to identify the framework of how such KMS may be built. The repository projects studied by Davenport, De Long, & Beers (1998) store knowledge that can be collected or gleaned from items such as documents (containing memos, reports, presentations, articles that may have (or be) knowledge and holding them in a repository available for retrievable by to others, or where individual experiences can be reported and combined with others' comments. They found that (1) external environmental knowledge; (2) structured internal organizational knowledge; and (3) informal internal knowledge were stored as *lessons learned* or as raw information with an added context and synthesis that made it more understandable and accessible (valuable). Some systems also include specialized routing on different topics to those organization members with specific interest in a topic.

Davenport, De Long, & Beers (1998) also discuss the unstructured, and otherwise undocumented knowledge residing in the minds of the people in an organization that is commonly referred to as *tacit* knowledge elsewhere. They note that it is transferred from individuals and incorporated into repositories, through community-based electronic discussion that can spread tacit knowledge via sharing that previously occurred though organizational socialization processes.

6. TRANSFER PROCESSING

Ingesting knowledge was one thing. But Davenport, De Long, & Beers (1998) noted a second major type of project focused in dissemination by delivering knowledge or transferring it among individuals. This enabled

ISSN: 2167-1508
v12 n5210

others to obtain what the organization or other individuals knew and methods of sharing the knowledge through increased connectivity.

Today's KMS must also address the new forms of data, some of which were discussed earlier in the paper. This means they will have to include techniques (such as those of sentiment analysis for Big Data). However, the systems must be capable of adding advanced techniques because the tools previously used to analyze these data are not ideally suited to leverage Big Data where significantly more sentiment analysis will be required. (Gandomi, & Haider, 2015).

7. EXAMPLES

Research and documented description of how KMS are built is scant. Research data and efforts focus on questions of theory and the application of KMS to specific projects rather that enterprise wide solutions. How such systems are built remains undescribed. For example, Research and empirical evidence on how knowledge is managed in alliances has been discussed in an integrative and organized framework that illustrates how the knowledge management outcomes of knowledge creation, transfer and application are determined by four distinct sets of factors: knowledge characteristics, partner characteristics, partner interaction, and active knowledge management (Schiuma, Andreeva, & Kianto, 2012). But how this knowledge is created, retained, retrieved (in and from a KMS) and applied and how the interplay of the different factors affects knowledge management in strategic alliances remain widely unexplored according to these authors.

The 2010 Haitian earthquake complex response effort relied extensively on knowledge management systems (KMS) describes as social media technologies such as wikis and collaborative workspaces as the main knowledge sharing mechanisms. This example also points to the specific focus of a KMS with knowledge sharing, reuse, and decision-making features. It asserts that knowledge was maintained in these systems. However, important research questions remain unanswered regarding social media as knowledge management systems (Yates, & Paquette, 2011).

Examples of knowledge management systems available commercially are found via various search tools. For example, Captera provides a vendor directory, and a survey of KM products that broadly describes come of the features and benefits (deployment, categorization, collaboration, content management, full text search, knowledge base management, self-service portal). However, there is no data or background information to ascertain if the assembly of modules approaches the development issues identified, and the systems cannot be readily mapped to the literature research guidance and question posed in table 1.

8. CONCLUSIONS

The evolvement of KMS will continue as cognitive research advances our appreciation and understanding of how decisions are influenced by knowledge derived from these systems. Organizational learning, individual performance and uses of individual skills, accumulation and transfer processes will also change. A greater understanding of how different kinds of KMS provide knowledge that can be captured, stored, and accessed for organizational use and decision making is known. KMS refreshment and renewal priorities, and how KMS may replace and support complex and changing work activities must be developed. Despres & Chauvel suggest that KMS will continue to evolve, and predict that a new model of knowledge for the Theory of the Firm will elucidate new tactical values, principles, and judgments (2012).

What is now understood of the ways knowledge is extracted and then employed from KMS is low. The theory of knowledge that is applicable to daily economic and applicable to business is not written or currently taught. How to build strong and renewable or defendable KMS within an organization is not well known. There is therefore much opportunity in examining and determining methodologies for developing and using KMS. There are many outstanding issues, or areas needing elucidation. Some of these are captured in the form of research recommendations in Table 1 below:

Issue for KMS Development	Literature finding/guidance	Research Recommendation
Wide Knowledge Content	Wide variety – static, dynamic. social	How to store and associate data types
Acceptance (deemed true)	Not addressed	Design formalized "certainty" process
Data – information – knowledge linage	Not Addressed	Hierarchical or indexing linking mechanism
Input - ingestion	Clean, filtering	Criteria maintenance
Processing	Sequences and steps; filtering; bi-directional	Acceptance; Bi-directional decision mechanisms
Success metrics	Meet "organizational goals"	Usage, access, value contribution
Project Approach	Structured	Compare to integration of current data and stores
Methodology	Hierarchical (step by step)	Comparison to Agile, DevOps
Environment	Cloud, hybrid	Transition, migration processes (for current knowledge)
Acquisition	Incremental, enterprise	Comparison – speed, acceptance, participation
Use, diffusion		
Dissemination process	Between individuals	Factors impacting use
Tools	Use existing now for target projects	Perform acer against new specialized KMS
Security	Internal firewalls, protection	Compare to cloud

Table 1. Research Recommendations

Associating KM with enterprise wide strategies, tactics, and operational activities may involve a deeper perspective of how individuals involves themselves with knowledge so they can constant learn and continually innovate. It is possible that KM systems may go beyond simplistic reasoning (without innovation) and deliver solid analyses of events and transactions by discovery of knowledge from database analytics. Intelligent agents must somehow then create and implement new actions that can become opportunities to provide services and positive results. The form that this will take cannot yet be predicted as knowledge as a social construct continues to emerge. One doctrine of KM is the need to arrange affairs to avoid rediscovering what earlier thinkers have created but maximize the reuse of valid knowledge and practices.

9. REFERENCES

Ackoff, R. L. (1989). From data to wisdom. *Journal of applied systems analysis*, *16*(1), 3-9.

Barr, J. (2018). "AWS Firewall Manager," Retrieved from https://aws.amazon.com/firewall-manager/

Barton, D. L. (1995). Wellsprings of knowledge: Building and sustaining the sources of innovation. Harvard Business School.

Benford, T. L., & Hunton, J. E. (2000). Incorporating information technology considerations into an expanded model of judgment and decision making in accounting. *International Journal of Accounting Information Systems*, *1*(1), 54-65.

Davenport, T. H., De Long, D. W., & Beers, M. C. (1998). Successful knowledge management projects. *Sloan management review*, *39*(2), 43-57.

Denning, S. (1998). What is knowledge management. *World Bank Knowledge Management Board, World Bank: Washington*.

Despres, C., & Chauvel, D. (2012). *Knowledge horizons*. Routledge.

Damodaran, L., & Olphert, W. (2000). Barriers and facilitators to the use of knowledge management systems. *Behaviour & Information Technology*, *19*(6), 405-413.

Dishaw, M. T., & Strong, D. M. (1999). Extending the technology acceptance model with task–technology fit constructs. Information & management, 36(1), 9-21.

Frické, M. (2009). The knowledge pyramid: a critique of the DIKW hierarchy. *Journal of information science,* 35(2), 131-142.

Gandomi, A., & Haider, M. (2015). Beyond the hype: Big data concepts, methods, and analytics. *International journal of information management*, *35*(2), 137-144.

Goodhue, D. L., & Thompson, R. L. (1995). Task-technology fit and individual performance. *MIS quarterly*, 213-236.

Hey, J. (2004). The data, information, knowledge, wisdom chain: the metaphorical link. *Intergovernmental Oceanographic Commission*, 26, 1-18.

Jennex, M. E. (2009, January). Re-visiting the knowledge pyramid. In *2009 42nd Hawaii International Conference on System Sciences* (pp. 1-7). IEEE.

Jennex, M. E. (2017). Big data, the internet of things, and the revised knowledge pyramid. *ACM SIGMIS Database: the DATABASE for Advances in Information Systems*, *48*(4), 69-79.

Jennex, M. E., & Bartczak, S. E. (2013). A revised knowledge pyramid. *International Journal of Knowledge Management (IJKM)*, *9*(3), 19-30.

Kankanhalli, A., Tan, B. C., & Wei, K. K. (2005a). Understanding seeking from electronic knowledge repositories: An empirical study. *Journal of the American Society for Information Science and Technology*, *56*(11), 1156-1166.

Kankanhalli, A., Tan, B. C., & Wei, K. K. (2005b). Contributing knowledge to electronic knowledge repositories: An empirical investigation. *MIS quarterly*, *29*(1).

Klopping, I. M., & McKinney, E. (2004). Extending the technology acceptance model and the task-technology fit model to consumer e-commerce. *Information Technology, Learning & Performance Journal*, *22*(1).

Newman, L. (2008). Descartes' epistemology.

Ormond, J., Dial, J., and Martin, O. (2017). "Microsoft cloud services and network security," Retrieved from https://docs.microsoft.com/en-us/azure/best-practices-network-security

Quaddus, M., & Xu, J. (2005). Adoption and diffusion of knowledge management systems: field studies of factors and variables. *Knowledge-based systems*, *18*(2-3), 107-115.

Ruggles, R. (1998). The state of the notion: knowledge management in practice. *California management review*, *40*(3), 80-89.

Sharma, N. (2008). The origin of the data information knowledge wisdom hierarchy. Data Inf. Knowl. Wisdom hierarchy.

Tech Target (2017). "Application Containerization," Retrieved from https://searchitoperations.techtarget.com/definition/application-containerization-app-containerization

Tiwana, A. (2000). *The knowledge management toolkit: practical techniques for building a knowledge management system*. Prentice Hall PTR.

Tzortzaki, A. M., & Mihiotis, A. (2014). A review of knowledge management theory and future directions. *Knowledge and Process Management*, 21(1), 29-41.

Tuomi, I. (1999, January). Data is more than knowledge: Implications of the reversed knowledge hierarchy for knowledge management and organizational memory. In *Proceedings of the 32nd Annual Hawaii International Conference on Systems Sciences. 1999. HICSS-32. Abstracts and CD-ROM of Full Papers* (pp. 12-pp). IEEE.

Wiig, K. M. (2000). Knowledge management: an emerging discipline rooted in a long history. *Knowledge horizons: the present and the promise of knowledge management*, *3*, 26.

Zeichick, A. (2017) "Understanding cloud-based firewalls," Retrieved from https://www.hpe.com/us/en/insights/articles/understanding-cloud-based-firewalls-1702.html