Organizational Memory/Knowledge Effects on Productivity, a Longitudinal Study

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Abstract

This paper discusses a longitudinal study that explored the relationship between use of organizational memory and knowledge (OM/K) and knowledge worker productivity within the engineering group at a nuclear power plant. Three data points were taken over five years. An OM/K System (OM/KS) was identified that improved effectiveness/productivity of the organization. The basic components of the OM/KS remained the same over the study. A key and unexpected finding was that new members of the organization did not consider the OM/KS as effective as established members and tended not to use the system until they became established members themselves. To explain the success of the OM/KS, DeLone and McLean's IS Success Model was adapted to OM/KS.

1. Introduction

Organizational Memory (OM) is defined by Stein and Zwass [16] as "the means by which knowledge from the past is brought to bear on present activities, thus resulting in higher or lower levels of organizational effectiveness.” Improving effectiveness can result in improved organizational performance and adding value to the organization. Strassmann [17], Rubin [14], and others propose that adding value to the organization or the organization's customer improves the productivity of the organization. What constitutes added value has been defined [14] as that added when the organization's performance is improved. Kaplan and Norton’s [9] Balanced Business Scorecard measures the value of IS to the organization. One aspect of the scorecard: Is the organization able to sustain learning and improvement, forms the basis for this study.

Huysman, Fischer, and Heng [7] as well as Walsh and Ungson [19] believe organizational learning has OM as a component. Learning is the process by which experience is used to modify current and future actions. OM is the stored information from an organization's history that can be brought to bear on present decisions [19]. Organizational learning uses OM as its knowledge base. Knowledge is an evolving mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information [4]. In organizations, knowledge often becomes embedded in documents or repositories and in the organizational routines, processes, practices, and norms [4]. This paper assumes knowledge is a subset of memory and will be referred to as Organizational Memory/Knowledge (OM/K). This relationship will be established later in the paper.

The proposition for this study was that Information Systems (IS) that incorporate OM/K are more likely to improve productivity. To find support for this proposition an engineer organization was selected for observation and data collection. An engineering organization was selected for the following reasons:

• Engineers are knowledge workers and make decisions as a part of their job function.
• Engineers use OM/K to make decisions.
• Engineer productivity is improved by increasing the speed and/or quality of the decisions they make.

This specific organization was selected because it was accessible and it was expected that the above was true. This organization resolves equipment and operational problems within a nuclear facility. They utilize performance and maintenance histories, lessons learned, and previous problem resolutions to arrive at new solutions or courses of action. How well they do this is reflected in how well the facility operates. The organization has approximately 100 engineers organized into groups that support specific facility systems or programs.

This paper reports the findings from a longitudinal study, covering 5 years, of this engineering organization. The longitudinal study was performed in three stages. The first stage was a case study with stages 2 and 3 being studies done two and five years later. The case study used models
from the areas of IS Productivity, End User Computing, and OM to generate and test the stated proposition. Stage 2 used surveys, interviews, and models based on the case study to validate the original findings, to see if the OM/KS was effective for new members of the organization, and to explore the relationships between memory and knowledge. Stage 3 used interviews and models from the previous studies to validate the OM/KS remained essentially the same, to test if new members grew to rely on and use the OM/KS as they gained experience, and to determine if the organization had a knowledge strategy.

Stage 2 was undertaken after the completion of a voluntary retirement program that resulted in over 25% turnover of the staff. This was perceived to be an opportunity to test if the OM/KS effect on productivity was due to familiarity of the individuals with their systems meaning that the OM/KS had little effect or that the OM/KS was key and that the level of experience of the users was less important.

Stage 3 was undertaken prior to a reorganization and reduction of the engineering units. This was perceived to be an opportunity to test if the OM/KS could be used to reduce potential losses of key knowledge, and in particular, to see if the organization had a KM strategy focused on reducing losses of key knowledge.

2. Literature Review

2.1. Organizational Learning

Organizational Learning (OL) can be defined as the process of "detection and correction of errors [10]." In this view organizations learn through individuals acting as agents for them with individual learning activities facilitated or inhibited by an ecological system of factors that may be called an organizational learning system. Huber [6] considers four constructs as integrally linked to OL: knowledge acquisition, information distribution, information interpretation, and OM.

2.2. Organizational Memory/Knowledge

OM is variously viewed as abstract or unstructured concepts and information that can be partially represented by concrete/physical memory aids such as databases; and as concrete or structured concepts and information that can be exactly represented by computerized records and files. This paper views OM as a combination of abstract and concrete where the concrete is the history and trend data collected in the memory and the abstract is the experience gained by the organizational member over time. Definitions by [16] and [19] were presented in the Introduction. Additionally, all agreed that OM can include everything within the organization that is retrievable including the set of documents and artifacts that forms the corporate record and the collection of shared and stored understandings and beliefs that forms the basis for organizational sense-making and social construction of reality.

OM has two principle goals: to integrate information across organizational boundaries and to control current activities and thus avoid past mistakes. Basic functions of OM are perception, acquisition, abstraction, recording, storage, retrieval, interpretation, and transmission of organizational knowledge [16]. It is expected that OM has five retention facilities: individuals, culture, transformations, structures, and ecology [19].

A definition of knowledge [4] was presented in the Introduction Nonaka [12] expands this definition by stating that knowledge is about meaning in the sense that it is context-specific. Comparing definitions of OM and knowledge suggests that knowledge is a subset of OM and that the acquisition and use of OM includes the acquisition and use of knowledge.

2.3. Knowledge Management

Knowledge Management (KM), as a discipline, has not been clearly agreed upon. KM is defined as that process established to capture and use knowledge in an organization for the purpose of improving organizational performance [11]. Organization refers to any acknowledged business group from a small team to the total enterprise. Also, this process is not restricted to the IS/IT organization and is better done in the organizations that create and use the knowledge. Personnel performing these functions are referred to as Knowledge Workers.

2.4. Organizational Memory/Knowledge Systems

In order to support the proposition that an IS that incorporates OM/K will improve productivity it must be shown that there is a OM/KS. The basic OM/KS structure was identified using a proposed framework consisting of two layers [16]. The first layer incorporates four subsystems that derive from four effectiveness functions. These subsystems are described in Table 1. The second layer consists of mnemonic functions including knowledge acquisition, retention, maintenance, search, and retrieval. These two layers can be either IT-based or non-IT-based but will consist of a combination of three possible forms: paper documents, computer documents, and self memory.

Paper documents are organization-wide references that reside in central repositories such as a corporate library. Examples of paper documents include reports, procedures,
and technical standards. An important part of this memory is in the chronological histories of changes and revisions to these paper documents as they reflect the evolution of the organization’s culture and decision-making processes.

Computer documents include all computer-based information that is maintained at the work group level or beyond. These may be made available through downloads to individual workstations, or may reside in central databases or file systems. Additionally, there are the processes and protocols built into the information systems that are reflected in the interface between the system and the user, by who has access to the data, and by the formats of structured system inputs and outputs.

Self-memory includes all paper and computer documents that are maintained by an individual. Typical components include files, notebooks, written recollections, and other archives. These typically do not have an official basis or format. Self-memory is determined by what is important to that person and reflects their experience with the organization.

It is expected that these forms of OMS will have overlapping information as shown in Figure 1. Spheres for self and others’ memory reflect that organizations consist of more than one person and that the knowledge/memory base will contain multiple self memories.

Sandoe and Olfman [15] suggest that the increasing transience of organizational workers will lead to a shift of the location of OM/K. They state that organizations will have to capture memory and store it in more concrete forms than they do today. They also suggest that an OM/KS should capture not only the traditional organizational file data found in information systems, but also the context, processes, knowledge, and experiences associated with this data.

2.5. Effectiveness of OM/KS

In order to support the proposition that IS that incorporate OM/K will improve productivity, the study has to show that the identified OM/KS is effective and has an impact on productivity. The following models were used.

Organizational effectiveness can be described using the competing values model [13] [16]. An implicit assumption of this model is that organizational effectiveness is related to OM/KS. This model uses four organizational effectiveness criteria that have been found to be consistent with effectiveness functions for actions systems. The OM/KS was found to be relevant to four functional clusters of effectiveness as described in Table 1.

<table>
<thead>
<tr>
<th>Effectiveness Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration</td>
<td>Coordination and management of information across the organization.</td>
</tr>
<tr>
<td>Adaptation</td>
<td>Ability of the organization to adapt to changes in its environment.</td>
</tr>
<tr>
<td>Goal Attainment</td>
<td>Ability of the organization to set goals and evaluate the degree of their fulfillment.</td>
</tr>
<tr>
<td>Pattern Maintenance</td>
<td>Ability of the organization to maintain the cohesion and the morale of the work force.</td>
</tr>
</tbody>
</table>

Figure 1. Repositories of Memory/Knowledge

DeLone and McLean [5] propose an IS Success Model. This model, Figure 2, is based on a review and integration of 180 research studies that used some form of system success as a dependent variable. It identifies six system success constructs and shows how they are related.

<table>
<thead>
<tr>
<th>Effectiveness Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Use</td>
<td>User satisfaction, information quality, system quality, perceived dual impact, organizational impact</td>
</tr>
<tr>
<td>System Quality</td>
<td>User satisfaction, information quality, system quality, perceived dual impact, organizational impact</td>
</tr>
</tbody>
</table>

Figure 2. DeLone and McLean’s [5] I/S success mode

2.6. End User Computing

Research in the evaluation of MIS and in predicting end user system usage provides a theoretical base upon which to construct a link between OM and productivity. The
literature provides validated survey instruments that can be adapted to this research. Colter and Dixon [3] described MIS evaluation instruments based on MIS success factors or information systems attributes. These were used to generate structured interviews. Thompson, Higgins, and Howell [18] conducted a study of workers' attitudes and behaviors with respect to optional computer usage. This work was based on Triandis' theory that the perception of future consequences predicts future actions. The implication was that the utilization of a PC in an optional use environment would be influenced by the individual's feelings, habits, and expected consequences of using PCs; and the social norms and environment governing PC use. They developed an instrument that was adapted to measure the relationships between social factors concerning OM use; perceived OMS complexity; perceived OM job fit; and perceived long-term consequences of OM use with respect to the utilization of OM. An additional factor, fear of job loss, was added to determine if that fear affected an engineer's willingness to contribute to the OM.

3. METHODOLOGY

To support the proposition that IS that incorporates OM/K will improve productivity data had to be collected on the constructs of OM/K, OM/K use, OM/KS effectiveness, and individual and organizational productivity. Since the sample size was not large enough for statistical testing, analysis was through means and variance. Additional data was collected during the last two studies with respect to OM/K strategy and new member OM/KS use. This data was also analyzed through means and variance.

The first study was an exploratory case study on OM, OMS usage, and productivity conducted within an engineering organization. A survey instrument from Thompson, Higgins, and Howell [18] was adapted to measure engineer attitudes of perceived job fit, social factors supporting OMS usage, OMS complexity, and fear of job loss. OMS and OMS effectiveness was modeled on [16]. Data was gathered using a survey instrument collecting data on components of the OMS, system usage, computer familiarity, and personal data; and structured interviews collecting data on components of the OMS, OMS effectiveness, and productivity. Productivity models based on ten years of performance history were generated from document research and interviews. The survey instruments were combined into a single survey and given to all 105 engineers, supervisors, and managers in the organization. A response rate of 79% was achieved on the survey. Interviews were held with 5 managers, 5 supervisors, and 11 engineers. Interview subjects were selected for their knowledge of the organization and its processes. The same interviewer conducted all the interviews. All data was collected within two months.

Stage 2 utilized a survey and selected interviews. The survey was an extract of the survey used in the first study with additional items for KM and KM strategy and was administered to all 98 members of the organization. A response rate of 21% was achieved on this survey. Interviews were conducted with ten members of the organization who were either new or had changed positions and were designed to determine if the OMS was usable by new personnel and if it transferred knowledge effectively. The same interviewer conducted all the interviews. All data was collected within two months.

Stage 3 used interviews and a document review. Twenty interviews were conducted. Six interviews were with the remaining new members from those interviewed during the second study. The remaining interviews were conducted with selected managers, supervisors, and engineers. Selection was based on participation in the previous studies. The repeat interviews followed the same script used in the second study. The remaining interviews were unstructured.

4. FINDINGS

4.1. Identifying OM/KS Components

Document research was used to generate a list of OM/K tools and repositories. A survey was used to gather data on the frequency of use for these tools and repositories. Interviews were used to finalize the OM/KS components. The outcome is a listing of repositories and systems that comprise the OM/KS.

The OM/KS consists of elements from all four forms as shown in Figure 1. These were found to be overlapping systems with each containing elements from the others. This was true for most IT components of OM/K due to process automation and reengineering replacing many documents and processes with IT substitutes. Stage 2 and 3 studies confirmed the OM/KS models with few changes. The most significant was a drop in importance of Email was due to changing the Email system from CCMail to Notes. The Email change was performed without converting Email archives with the effect that Email based OM/K was lost. This experience taught the organization not to rely on Email as a repository.

4.2. OM/KS Use

Use was assessed using two different methods. The case study used a survey to measure current OMS usage and the perceived benefit of the OM/KS based on the Perceived Benefit Model [18]. The survey found that the engineers used the OM/KS extensively, an average of 2.9 hours per day. Table 2 summarizes the findings for each of the
perceived benefit factors (5-point Likert scale, 5 is strongly agree) and leads to the finding that the OM/KS is effective because it is and will be used. This survey was not repeated in the stages 2 and 3 studies as interviews showed that the OM/KS was still being relied upon and used. Had the interviews showed declining use or interest in the OM/KS then the survey would have been redone.

4.3. Effectiveness of the OM/KS

The Competing Values Model [16] was used to assess OM/KS effectiveness. Table 3 summarizes these findings. Data was collected via interviews in the case study, coded and analyzed using a 5-point Likert scale (1 is strongly agree). Elements of these interviews were used in stages 2 and 3 to confirm continued effectiveness. This model supported an effective OM/KS throughout the study.

Table 2, Perceptions Affecting Usage

<table>
<thead>
<tr>
<th>Perceived Benefit Factor</th>
<th>Score</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social factors</td>
<td>4.08</td>
<td>environmental support for using OM/KS found</td>
</tr>
<tr>
<td>Complexity (inverse scored)</td>
<td>2.38</td>
<td>not complex, support for using OM/KS found</td>
</tr>
<tr>
<td>Job fit, near term consequences</td>
<td>4.56</td>
<td>fit job well, support for using OM/KS found</td>
</tr>
<tr>
<td>Job fit, long term consequences</td>
<td>3.36</td>
<td>neutral</td>
</tr>
<tr>
<td>Fear of Job Loss</td>
<td>2.32</td>
<td>no support, no fear found</td>
</tr>
</tbody>
</table>

Table 3, Results of Effectiveness Functions

<table>
<thead>
<tr>
<th>Factor</th>
<th>Score</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration</td>
<td>2</td>
<td>Good time/spatial integration, support effective OM/KS</td>
</tr>
<tr>
<td>Adaptation</td>
<td>2</td>
<td>Boundary spanning done, outside information brought in, supports effective OM/KS</td>
</tr>
<tr>
<td>Goal Attainment</td>
<td>1</td>
<td>Goals/ performance tracked, support effective OM/KS</td>
</tr>
<tr>
<td>Pattern Maintenance</td>
<td>1.5</td>
<td>Procedures/revisions, individual skills tracked, supports effective OM/KS</td>
</tr>
</tbody>
</table>

Qualitative analysis of effectiveness utilized structured interviews that asked for opinions and examples on the effectiveness of the OM/KS. A consensus was found that the OM/KS made the subject audience more effective. Nearly all agreed that most past decision information could be retrieved within a couple of hours and usually within minutes. Also, nearly all agreed that the OM/KS could be better. Elements of these interviews were used in the stage 2 and 3 studies with the same results. Examples of comments include:

“It (the OM/KS) helps us to keep from reinventing the wheel. Every decision we make is not a new decision. Our systems help us to do this.”

“We have much more capability now than we did. As a Shift Technical Advisor (STA) we can do so much more than we could ten years ago. There is almost too much data.”

“The information is there but the tools are slow, systems crash, and the information and tools are unreliable.”

While the OM/KS is considered effective, it was found wanting in the areas of hardware and overall integration. Users who had a PC with less than a Pentium processor (during the case study) or a lower level Pentium (during the stage 2 and 3 studies) found the systems slow and cumbersome. Lack of adequate RAM was a common issue (initially 32 Mbytes were needed, expanding to 128 Mbytes for the final study, in each study over half the subjects had PCs with half (or less) of the necessary RAM). Also, users noted that there were many tools and sources but no observed intentional cohesion between them. It was noted that all the systems are on Windows so that data could be copied/cut and pasted, thus providing a basic level of integration. However, no master plan for developing or maintaining the OM/KS was developed during the study and no evidence was found suggesting this would ever be done. This suggests that the OM/KS will continue to lack cohesion and will not improve in effectiveness. The two observed changes in the OM/KS actually reduced effectiveness by increasing access times. Also, reducing dependence on Email, while better for reliability, accuracy, and security, reduced individual effectiveness by removing an easy to use, readily accessible repository.

4.4. Characterizing Productivity

The standard measure for productivity is resources used for products generated. This does not apply to many engineers. Instead, effectiveness was used as a measure of engineer productivity. The case study explored this definition of productivity and found support for it. Interviews determined what measures the managers used to evaluate their engineers and to identify what measures the engineers’ thought should be used. While no one set of measures was identified, several factors were found that when combined could be used for this measure:

- Timeliness in completing assignments
- Number of assignments completed
- Identifying and completing high priority assignments
• Completeness of solutions (all the bases are covered)
• Quality of solutions (well written with complete documentation)
• Solving problems right the first time
• Amount of work that has to be repeated
• Complexity of work that can be assigned to a worker
• Amount of backlog

This is a mix of qualitative and quantitative measures, most of which are influenced by the effectiveness and use of the OM/KS. This supports the research proposition.

Identifying productivity measures for the organization was more difficult than identifying them for the engineers. Three approaches were used. The first looked at the performance assessments done by external organizations. The second looked at performance relative to the goals in the business plan. The third looked at performance relative to preset key performance indicators.

The first measure used the SALP, Systematic Assessment of Licensee Performance, Reports issued by the NRC. Review of scores issued since 1988 showed an increase from a rating of 2 to a rating of 1 in 1996. This rating was maintained through the 5 years of the study.

The other part of the external evaluation process is the site evaluation performed by the Institute of Nuclear Power Operations, INPO. An evaluation was conducted during the spring of 1996 and resulted in a 1 rating. This rating was also maintained throughout the 5 years of the study. A history of these ratings was not provided as they are considered confidential by INPO and are not released to the public.

The external assessments identified several strengths directly related to engineer productivity. These include decision-making, root cause analysis, problem resolution, timeliness, and Operability Assessment documentation. This demonstrates a direct link between engineer productivity and organization productivity. Also, since organization productivity is rated highly, it can be inferred that engineer productivity is high.

The second method was to look at performance relative to the business plan. The first study found very few goals related to the subject organization and few performance indicators and goals that could be used to determine productivity. Two indicators were linked to OM/K: unit capacity and unplanned automatic scrams. Unit capacity and unplanned scrams are influenced by how well the engineers evaluate and correct problems. Both factors improved over time. These two factors plus unplanned outages and duration of outages became the standard measure during this study. Reporting and monitoring of these factors significantly improved during the study. Originally, information on how the site was performing was distributed infrequently with little attention paid to it. During the last 2 years, as management became more aware of OM/K and measuring their own effectiveness, the process was changed. Currently, performance information is available on the site’s Intranet. Also a quarterly report is produced that discusses how the site is performing and pays particular attention to lessons learned, what is working well, what isn’t working well, and where there are problems. Originally, this method was not considered effective as a measure of effectiveness. However, it is not considered to be a very effective measure and has replaced the first method as the method of choice for assessing organizational effectiveness.

The third productivity measure used performance indicators selected by the subject organization. These indicators are monitored monthly and graphs illustrating performance are printed and posted.

This method provided less than useful results. It does tie in well with the overall organization's goals as defined in Method 2, but only addresses the quantifiable measures of the engineer productivity model. Since OM primarily affects the qualitative and competency skills aspects of engineer productivity, this method does not provide any insight into whether or not OM improves productivity. However, this method was rolled into Method 2 and is now used to report quantifiable results as well as to report on qualitative measures such as lessons learned.

4.5. Assessing OM/KS Effectiveness for New Users

The Stage 2 study came after a voluntary retirement program was completed. Ten interviews were conducted with personnel who were either new to the organization or to their position. Consensus was found that the computer-based portions of the OM/KS contained the appropriate information and was accurate. They also agreed that the computer-based portion of the OMS was not effective. Examples of comments supporting this finding included:

“Sure all the information is in the computer but the computer isn’t as fast as simply asking the previous guy.”

“Not only does asking the previous engineer get me the answer faster but he can guide me to other sources and interpret my questions to give me the answers I need.”

“I treat all events as new events because its easier and faster to get the information I need to fix the problem than it is to research the system about what happened before.”

This was an unexpected finding. After reviewing the interview data it was postulated that new users did not have an understanding of the context for the knowledge they accessed on the system. It was further postulated that given time, the new members would start using the OM/KS.

The Stage 3 study interviewed the remaining new
5. LIMITATIONS

The subject organization has similarities to, but is not typical of, conventional engineering organizations. This limits the external validity of the findings. However, the organization was chosen because it was known that it used OM/K. This ensured that there was OM/K data to be collected. This was more important than the ability to generalize the results. External validity can be improved by replicating this research in other organizations.

There are threats to internal validity. There is a selection threat to the interview data due to the selection process used to choose interview subjects, there may be a history effect, and there are small instrumentation effects. Also, Stage 2 had a lower, 21%, response rate. None of these effects are considered serious enough to invalidate the findings of the study. The low response rate for Stage 2 is acceptable as the interviews backed up the survey results and informal discussions with organization members found that they did not respond because they saw no differences to discuss.

There are threats to construct validity due to using an interviewer who had been a member of the subject organization and the constructs themselves. Steps were taken to minimize these threats and the value of the information gathered outweighs the potential loss of validity.

This study is determined to have a high degree of reliability. A test-retest methodology was followed in determining the OM/KS. The OM/KS was then validated twice. Document research determined the initial list of components. Surveys were used to narrow the list of components to those that formed the base OM/KS. Interviews of selected survey respondents were used to verify the results of the survey. Multiple measures and sources of data were used to determine organizational productivity, OM/KS usage, and OM/KS effectiveness. In all these cases, the multiple measures and data sources converged to the same conclusion. The one weakness is individual productivity. No models were used to generate measures for evaluating this construct. Interviews were used to determine what the organization used. No overall model was found but the interviews showed there was a high degree of concurrence on the factors that constituted productivity. These factors were used to generate a model of individual productivity. The measure used to evaluate individual productivity was simply that of asking interview subjects if they believed they were more productive now than they were five or ten years ago. This is subject to random error but it is determined that this error is very small due to the huge degree of agreement between the respondents.

In summary, this study has high reliability and moderate validity. There is limited external validity and some internal validity and construct validity threats were not controlled. There is also a possibility that the results are random. High reliability minimizes random errors in measurements. Using multiple sources of information improves validity and minimizes the possibility that the results are random. However only one organization was used so the results being random cannot be eliminated.

6. CONCLUSIONS

Memory happens. Planned or unplanned, individuals and organizations will find a way to remember past decisions and events. Why? Because it is cost effective to not re-invent the wheel or to start from scratch each time a decision has to be made. The original proposition was that IS that incorporate OM/K are more likely to improve productivity. This was found to be true. Although a great deal of quantitative data was taken, it was not possible to quantify productivity gains as a function of OM/KS effectiveness. The OM/KS was found to be effective and to have improved in effectiveness over a five year period. The engineers were found to be more productive and much of the improvement was attributed to better systems, including improved OM/KS components. This finding was expected.

Two unexpected findings were noted. The first is that the ability to use OM/K and the OM/KS are considered basic skills by most members of the organization. This
implies that measures can be developed for OM/KS proficiency. This strengthens ties between OM/K, OM/KS usage, and productivity. The second is that the OM/K needs of the OM/KS user vary depending on their experience level in the organization. Context of the OM/K is critical. New members do not have this context. This OM/KS did not store sufficient context for a new member to understand and use the stored OM/K. It was found that new members need linkages to the human sources of OM/K. It is not expected that OM/KS’s will ever be able to do an adequate job of storing context so it is recommended that the OM/KS store linkages to OM/K. This is consistent with Davenport and Prusak [4].

Several models were used for this study. The Competing Values Model [16] needs to be expanded to include evaluating reliance on personal memory as an OM/K repository and overall system integration. The perceived benefit instrument [18] for predicting system usage was found to be a useful tool. The authors continue to use it to determine if an organizational culture will support using an OM/KS.

Two models were generated to represent conclusions from this study. The first model relates KM, OM, and OL. The second model modifies the IS Success Model [5] to reflect the needs of OM/KS. Both are discussed below in detail.

6.1. Relationship Between KM, OM, and OL

An outcome of this study is that there is a relationship between Organizational Learning (OL), Organizational Effectiveness, KM - KM Systems (KMS), and OM - OM Systems (OMS). The first study established a relationship between Organizational Effectiveness, OM/K, and the OM/KS. Stage 2 looked at what drove users to contribute to the OM/K. That study found a number of formal and informal drivers existing in the engineering processes. The finding is that KM and OM are postulated to be manifestations of the same process but in different organizations. KM is what user organizations do, they identify key OM/K for retention and establish processes for capturing it. OM is what IT organizations support They provide the infrastructure and maintenance for storing, searching, and retrieving the OM/K. Figure 3 illustrates these relationships. Stage 3 looked at the organization through this framework to determine if the process existed. It was found to exist.

Figure 3. The OM/KS Model

That OL may not always have a positive effect is allowed by the monitoring of Organizational Effectiveness. Effectiveness can improve, get worse, or remain the same. How effectiveness changes influences the feedback provided to the organization using the knowledge. Huber’s four constructs for learning are reflected in the KMS and OMS bubbles. Figure 3 also illustrates that KM and OM, and the KMS and OMS, are separate functions performed by possibly different organizations where the organizations may be smaller units in an enterprise or even completely separate organizational enterprises. It was found that a separate engineering change management group handled KMS functions for the engineering group. KM and the KMS are the process and system used by Knowledge Engineers in knowledge using organizations to identify and capture knowledge for future use. OM and the OMS are the process and system used and created by the System Developers in the IT organization to provide storage, search, and retrieval infrastructure functions for the management of knowledge. Together, the KMS and OMS form the total system. Figure 3 shows that the KMS and OMS, while separate functions, operate together, forming a single system, what in this paper has been referred to as the OM/KS. This also was observed during Stage 3 as members of the IT organization were called in to provide infrastructure support for engineering’s OM/K efforts.

6.2. Assessing OMS/KMS Success

This study assessed the effectiveness of an OM/KS by deriving productivity/effectiveness measures from the organization’s performance metrics. This paper culminates efforts by Jennex et al. [8] to generalize assessment of OM/KS success by adapting the IS Success Model [5] to OM/KS. Figure 4 is the model adapted for OM/KS. The model is a block-recursive one that includes 5 blocks.
System Quality. This block defines the system quality in terms of the technical characteristics of the OM/KS as described by three constructs: the technical resources of the organization, the form of the OM/KS, and the level of the OM/KS. Technical resources define the capability of an organization to develop and maintain the OM/KS. These include aspects such as amount of experience already gained in developing and maintaining an OM/KS, the amount of technical expertise that is used to develop and maintain the OM/KS, the type of hardware used to run the OM/KS, and the competence of the users. Quantitative aspects include usability of interfaces, speed of functions, system availability and reliability, and the use and capacity of a network infrastructure. Qualitative aspects include documentation and maintainability of the system, compatibility between system components, expandability, and adaptability to individual users.

The form of OM/KS refers to the extent to which it is computerized and integrated, explicitly, how much of the accessible information/knowledge is on line and available through a single interface. The key aspect is the coherence of the logical knowledge base structure. This is influenced by the Technical Resources of the system. Quantitative aspects are the quantity of information/knowledge available on line and the number of distinct sub-systems searched to retrieve the desired information/knowledge. Qualitative aspects include degree of normalization of database structures and the effort required to maintain data integrity.

The level of the OM/KS refers to its ability to bring past information to bear upon current activities. This refers explicitly to the search and retrieval functions of the system and is influenced by the technical resources and Form of the system. Quantitative aspects of this construct are the speed in which information/knowledge can be retrieved and the completeness of the search function. The qualitative aspect is the ease of search and retrieval, can it be done on line or with minimal physical effort and are queries easy to structure and communicate.

Given the effectiveness of information technology to provide timely information, it is expected that a more fully computerized system utilizing network and data warehouse technologies will result in the highest levels of system quality.

Information Quality. Davenport and Prusak [4] discuss two primary types of knowledge, links to experts who serve as sources of knowledge and rich, detailed knowledge. This study found that OM/KS users new to an organization utilized knowledge linkages most. More experienced members of the organization relied on retrieving detailed, accurate, and timely OM/K from the OM/KS. A successful OM/KS should be able to support both new and experienced users so both are included in the model. Quantitative aspects of these constructs are completeness, accuracy, and currency of linkages and information/knowledge. Qualitative aspects include how well the information/knowledge is communicated, specifically its richness in expression and detail.

The third construct, KM Strategy and Process, reflects that the knowledge needs of the OM/KS users change over time. KM Strategy is needed to determine what information/knowledge should be in the knowledge base, where it is located, and how it is to be acquired. The KM Process is necessary to ensure that knowledge requirements are reviewed on an ongoing basis. Quantitative aspects are timeliness and amount of resources dedicated to the plan for revisions and/or entry of information/knowledge. Qualitative aspects include relevancy and completeness of the information/knowledge identified for acquisition. Qualitative aspects can be made quantifiable by applying impact success measures for individuals and organizations using the OM/KS, this is reflected as the feedback path in Figure 3.

Use. OM/KS use refers to the utilization of the outputs of the system. This construct is most applicable when use of a system is required. User satisfaction is a construct that measures perceptions of the system by users. It is considered a good surrogate for measuring system success when use of the system is voluntary and degree of use would depend on meeting user expectations. Also, both constructs provide feedback to each other, especially where use is voluntary. A more satisfied user might be expected to increase usage. This study used the perceived benefit model [18] to measure user satisfaction and predict continued use of the OM/KS. This measure was found to work well and is included in the user satisfaction construct. The studies suggest that a combination of the two constructs can be used to measure use. Quantitative aspects are actual OM/KS usage and user satisfaction. Qualitative aspects are perceived benefits of the OM/KS.

Individual and Organizational Impacts. An individual’s use of a system will produce an impact on their performance. In addition, [5] notes that an individual ‘impact’ could also be an indication that an IS has given the user a better understanding of decision context, improved

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**Figure 4.** The OM/KS Modified IS Success Model.

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their decision-making, changed user activity, or changed the decision maker’s perception of the importance or usefulness of the IS. Each individual impact will in turn have an effect on the performance of the organization. Organizational impacts are typically not the sum of individual impacts, making the association between individual and organizational impacts difficult to draw. Quantitative aspects of these constructs are the explicit measures defined by organizations as indicators of success. These measures are typically known as KPIs, Key Process Indicators. KPIs may be written explicitly for the OM/KS or may be generic to total performance of the individual or organization in which case relationships between use of the OM/KS and the KPI will need to be identified. Qualitative aspects are Manager Perceptions. These are subjective opinions of how the OM/KS have affected performance of the individual or organization.

7. REFERENCES