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Research Article

Embedding Knowledge Management into Business Processes

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The paper examines how knowledge management may be used to achieve business process improvement by embedding knowledge management within problem processes. The paper presents knowledge as skilful knowing, and this occurs at the individual, group, and organizational levels. How the organization manages skilful knowing at these three levels is determined by its knowledge management. The paper applies lean thinking principles to identify inefficiencies in workflow and knowledge flow, which we call waste points. It then applies a knowledge management conceptual framework to identify why these waste points exist and to surface solutions. Knowledge management is then embedded into the problem processes to remove the waste points, allow knowledge to flow, and improve the efficiency of workflow. The results are based on a case study of three Saudi Arabia universities. The results have implications for researchers and practitioners. Copyright © 2017 John Wiley & Sons, Ltd.

INTRODUCTION

The use of knowledge management (KM) in business process management has become widely accepted (e.g. Linderman *et al*., 2010). Business process management is organizational transformation leading to improvements to business performance and innovation (Harkness *et al*., 1996). Business process change designs business processes to achieve significant change in terms of quality, cost, flexibility, and responsiveness through changes in the relationships among management, information, and technology (Guha *et al*., 1997). Knowledge and KM help achieve process change. Researchers have aimed to integrate business process management and KM in process-centred knowledge models (e.g. see Raghu and Vinze, 2007; Jung *et al*., 2007; Han and Park, 2009). The focus of this previous research is to develop capabilities leading to effective KM such as knowledge synthesis, knowledge storage and retrieval, and knowledge sharing (Raghu and Vinze, 2007) or knowledge creation (Linderman *et al*., 2010). This approach considers KM as a separate organizational system (OS) and uses process management to improve it. This paper develops an alternative approach which embeds KM into business processes as an integrated system rather than a separate one.

Knowledge management emerged in the 1990s from the strategic management literature's knowledge-based view of the firm (Grant, 1996). This theory argues that tangible resources create value from how they are combined and applied which is a function of know-how (knowledge), and this is embedded in multiple entities including organizational culture, policies, systems, documents, and individual employees (Alavi and Leidner, 2001). Knowledge met the criteria for sustainable competitive advantage, particularly that it was difficult to imitate and socially complex (Grant, 1996). KM attracted interest amongst researchers and practitioners from multiple disciplines. This has caused problems in terms of definitions and language, and there is a lack of consensus between disciplines.

A major cause of disagreement is whether knowledge may be separated from the knower (e.g. see Tsoukas, 2003). This raises important questions about the relationship among knowledge, technology, and social interaction at work. It also presents an opportunity to clarify this paper's epistemological and ontological positions. Knowledge is typically classified as codified (or explicit), for example, policies, reports, procedures, databases, and tacit (or implicit), for example, the knowledge in people's heads (Polanyi, 1962). Knowledge may be viewed as objective, in the sense that it is

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independent of human perception or subjective in that it is personal and context-sensitive (Sabherwal and Becerra-Fernandez, 2003). This distinction may be described as know-what knowledge, that is, reading codified knowledge about the task such as a policy is sufficient, or know-how; that is, it may require practice or discussion (Edmondson *et al*., 2003). Tacit knowledge is often grounded in action or is context specific (Nonaka, 1994). Knowledge may, therefore, be defined as the set of justified true beliefs that enhance an entity's capability for effective action (Sabherwal and Becerra-Fernandez, 2003). The interpretation of justified truth is influenced by whether you adopt an objective or subjective view; the former separates knowledge from the knower, and the latter does not.

This paper examines how KM may help process management. Therefore, it adopts an activity or practice-based view of knowledge (Aakhus, 2007). According to Polanyi, knowing involves 'skilful action' (cited by Tsoukas, 2003). This means that knowledge emerges in the act of doing something. It is only in the act of doing that the individual becomes fully aware of the knowledge necessary to complete the activity. This paper uses lean thinking to explore how skilful knowing will reduce or eliminate waste and increase efficiency in workflow. It assumes that unskilful knowing creates waste because the individual lacks know-what or know-how knowledge (e.g. see Edmondson *et al*., 2003), and this causes delays. The activity of moving from unskilful knowing to skilful knowing in the act of doing is a controversial topic. The technology view of KM proposes that the unskilful individual will use information technology to identify and then use knowledge which has been captured by their organization to help them become skilful (e.g. see Kearns and Lederer, 2003). The personalization view of KM proposes that this individual will work it out for themselves, that is, learn by doing, or seek help from others (Gardner, 2012). Researchers have recognized the shift from technology towards socialization (e.g. see Hansen and Haas, 2001; Hansen, 2002; Berry, 2015). The paper examines how to embed KM within wasteful process by enabling skilful knowing in the act of doing.

This paper proceeds as follows. First, a brief review of relevant literature is presented. Then, the research methods, including the case study organization, are described. The research data were based on a longitudinal study of Saudi Arabia's three leading research institutes. Saudi Arabia is a wealthy nation that has been able to buy necessary knowledge wherever required. This occurred through its research institutes hiring overseas experts to visit for periods. However, the government became concerned that local staff were not learning sufficiently from overseas experts. It was felt that if the research institutes were to become world class, they needed to grow local capability, and this meant improving the flow of knowledge from overseas experts to local staff. This paper is based on this study. Findings from this case result in a process-centred KM model from a personalization perspective. Finally, conclusions and limitations of the study are discussed.

THEORY AND LITERATURE REVIEW

Knowledge

Knowledge is skilful knowing in the act of doing work. Knowledge may be broadly defined as credible information that is of potential value to an organization (Tomas and Hult, 2003). Researchers explain that this value is created in the act of doing work. For example, Chen *et al*. (2010) define knowledge in terms of the ability to do task assignments, Sabherwal and Becerra-Fernandez (2003) describe it as capability for effective action, Linderman *et al*. (2010) focus on organizational routines or patterns of action, while Sarvary (1999) defines knowledge in terms of inputs, which is raw information such as an individual's experience and data gathered elsewhere, and outputs, which is how the inputs are used to solve business problems. These definitions describe how knowledge is created, shared, and used in the activity of doing work. This paper focuses, therefore, on tacit knowledge, due to its action and context specificity (Nonaka, 1994), and on the achievement of skilful knowing within a process.

Knowledge is commonly represented as technical knowledge or cognitive knowledge (e.g. see Nonaka and Takeuchi, 1995). Technical knowledge may be described as discipline-related or subject-matter expertise. In a university context, which is the case study in this paper, it may be described as engineering, physics, or robotics (discipline knowledge) or writing a research grant or preparing a lecture (subject matter expertise). Cognitive knowledge may include other non-technical knowledge unique to the individual's work context such as behaviours, attitudes, and social capital. This is the individual's process of making sense of the world and may include judgment, intuition, and perception.

Researchers have suggested that the application of both technical and cognitive knowledge is mediated by private and cultural models generated by the individuals' own cognitive dispositions, including memory and emotions, as well as socio-cultural interaction (Ringberg and Reihlen, 2008). This socio-cognitive approach to knowledge explains that the individual's environment, conceptualized as OSs, helps define the individual's knowledge. As the individual does work, cognitively processes exchange within the broader strategy, structure, and culture of their organization to help them find meaning

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(Ringberg and Reihlen, 2008). This thinking has developed a paradigm that views knowledge as a systemic, socially constructed, context-specific representation of reality (Parent *et al*., 2007). This reality may be found by the individual themselves working alone, for example, individual know-how, by working with others, for example, group know-who, or by accessing codified knowledge, for example, organizational know-what.

The personalization view of KM proposes that tacit knowledge may be gained, that is, the act of skilful knowing, by individuals, groups, or organizations. Tacit individual knowledge, that is, know-how, is the act of learning by doing. Tacit group knowledge, that is, know-who, is the act of accessing social capital. Tacit social capital is organizational knowledge found within unique organizational context and work situations. Tsoukas and Vladimirou (2001) call this a corpus of generalizations. It is 'how we do business around here'. It is much more than the norms and values of organizational culture. It is a secret recipe of business success within this unique organizational context. It is secret because only organizational members can access it and it is usually not written down in any codified form such as policies or procedures; otherwise, it would be structural capital. Individuals can only access this knowledge through social interaction with those in the know, that is, other organizational members who know the corpus of generalizations. Further, individuals will vary in their capacity to access this knowledge. Each individual has only a partial view of knowledge about a particular organizational routine or practice (Newell *et al*., 2006). Tacit organizational knowledge is integrated across groups and communities. It is often described as structural capital, captured in databases, policies, procedures, and reports.

This discussion presents knowledge as skilful knowing, and this occurs at the individual, group, and organizational levels. How the organization manages skilful knowing at these three levels is determined by its KM.

Knowledge management

Process management defines KM as a series of separate activities, for example, synthesis, storage and retrieval, and sharing (Raghu and Vinze, 2007). This means that KM is regarded as separated from the activity of work itself; for example, it is an enabler. In this sense, KM is a business process itself (Sarvary, 1999), which helps organizations create and use knowledge. The way that this process is performed has many interpretations. Nonaka and Takeuchi's knowledge-creating spiral (Nonaka and Takeuchi, 1995) is often used to explain how knowledge is created and diffused across the three levels of individual, group, and organization (e.g. see Sabherwal and Becerra-Fernandez, 2003; Jung *et al*., 2007).

The technology view sees KM as information-seeking behaviour. If an individual does not know something, then they use technology to help find the answers (e.g. see Kearns and Lederer, 2003). This is about knowledge capture and codification (e.g. see Alavi and Tiwana, 2005). The technology view dominated the early evolution of KM; however, recent research has placed technology as a support function rather than the main driver of connectivity (Aakhus, 2007). On the other hand, the personalization view looks at social practice as the best way to manage knowledge (Gardner, 2012). The implication is that learning comes from cultivation of judgment rather than acquisition of information (Aakhus, 2007). Knowledge comes from interaction and debate where people work out the truths, commitments, perspectives, and identities central to their work (Aakhus, 2007). People find justified true belief via interaction with other people, not via interaction with technology. This is about providing opportunities for people to socialize in real, for example, meetings, or virtual environments, for example, online (e.g. see von Krogh, 2005).

The discussion so far has looked at how individuals, groups, or organizations become skilful knowers, that is, move from unskilful knowing to skilful knowing within a process. The technology and personalization views provide contrasting ideas about how this is carried out. This paper builds a connection to process management by examining the act of skilful knowing. Researchers have accepted that knowledge is created and used during the 'execution of business processes' (Han and Park, 2009: 7441) and, therefore, value is created by the individual in the activity of doing work. This argues that if knowledge is 'separated from the business process context, it does not lead to the ability to take the right action for target performance' (Han and Park, 2009: 7441). This means that knowledge loses value if it is separated from its context, that is, how it is used to perform work.

This paper proposes a view of process-centred KM driven by the individual in the act of doing. This conceptualization sees work as an adaptive process where the individual tries to turn given situations into preferred situations (Aakhus, 2007). Rather than follow bureaucratic guidelines, professional practice involves a process of problem-framing and problem-solving based on the individual's theory of practice (Schon, 1983). The individual uses their experience to make sense of the work situation. In this way, knowledge involves not only technical knowledge but also judgment, that is, the competence of handling complexity, instability, and value conflict when engaging people and problem situations at work (Schon, 1983). This view focuses on individual knowledge because it allows the individual to learn from their experience, that is, reflect in

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practice, and to apply this to a new work situation. It recognizes that knowledge may be created within a group and produce collective know-how (e.g. Edmondson *et al*., 2003) and even across and between organizations and produce organizational know-how (e.g. see Reagans and McEvily, 2003). This paper adopts the personalization perspective of KM focusing on how individuals address unskilful knowing within the business processes associated with doing their work.

Process management

The aim of process management is organizational transformation resulting in sustained process improvement (Harkness *et al*., 1996). From this perspective, KM contributes to process management via systems, technologies, and tools which enable knowledge to be captured, stored, and shared to benefit the organization (Becerra-Fernandez and Sabherwal, 2010). Process-centred KM tends to focus on separating knowledge from the knower, that is, the technology view of KM (e.g. see Sabherwal and Sabherwal, 2005). This previous research focuses on knowledge as an informational product presents a technocratic conceptualization of work. It sees work as information-seeking behaviour. This fits with the definition of process management itself which is 'to design, control, improve, and redesign processes' (Silver, 2004, p.274). This focuses on codifying and capturing knowledge by writing it down. The technology view focuses on organizational knowledge because it asks the individual to follow the organization's guidelines rather than think for themselves.

Recent research recognizes that process management and KM should be unified rather than operate as separate OSs. This is achieved by attaching knowledge to tasks, so that individuals capture and use knowledge as part of their normal work (Han and Park, 2009). In this way, knowledge is embedded in business processes (Han and Park, 2009). This literature has taken two paths in this topic. The first highlights the importance of knowledge about the process itself, referred to as process knowledge (Jung *et al*., 2007). This includes definition of the process and its mapping, referred to as process template knowledge; performance measures evaluating its value, referred to as process instance knowledge; and awareness of how the knowledge is created and used, referred to as process-related knowledge (Jung *et al*., 2007). The second path looks at KM activities, such as knowledge creation, as an outcome of process management developing a set of dynamic capabilities leading to sustainable competitive advantage (Linderman *et al*., 2010). This view examines how process management creates knowledge which becomes embedded as organizational routines. Linderman *et al*. (2010) explore how process management leads to effective knowledge creation by factors associated with monitoring and changing the activity, such as leadership, culture, design, technology, and human resources.

Raghu and Vinze (2007) develop a model of business process context for KM incorporating four key aspects of the operational core of knowledge: workflow execution, information processing, decision making, and motivational structure. This model includes the technical view of KM (information processing) with the need for work context (workflow execution) and the individual system of knowledge (decision making and motivation). In this paper, the embedded model of process-centred KM is connected to process management through workflow execution. Workflow concerns usually surround issues of efficiency and flexibility (Raghu and Vinze, 2007). The technology view of KM aims to increase workflow efficiency by reducing hand offs and increasing automated tasks within the process (Han and Park, 2009). The personalization view of KM aims to increase efficiency by reducing time spent accessing necessary knowledge about the tasks within the process via information systems, social capital, or learning by doing. This paper uses lean thinking to explore time and efficiency in workflow.

Lean thinking

Lean thinking has become accepted by academics and practitioners as the dominant approach in manufacturing management (Boyle *et al*., 2011). The goal of lean is to determine waste in the value stream, to eliminate those wasteful activities, and to create and sustain value-added activities (Chongwatpol and Sharda, 2013). Waste may be visualized as blockages which impede the flow of work, information, or knowledge within an organization. The issue of waste is a concern for many organizations (Hines *et al*., 2004). Waste usually leaves business processes functional but not functioning at an optimal level (Harrington, 1991). Lean thinking provides a way to manage problems caused by waste points by specifying value, improving alignment of value creating activities, understanding the way activities may increase effectiveness, and reducing the time to perform tasks (Womack and Jones, 1996).

This paper uses lean thinking to identify and resolve workflow inefficiencies. The philosophy of lean thinking focuses on eliminating waste within business processes (Chongwatpol and Sharda, 2013). There is a complex interaction between KM and workflow structure (Raghu and Vinze, 2007). This interaction is explored by how individuals learn from the application of knowledge in a process and then share these lessons learned with their organization via problem solving and documentation. It is at this point that this paper diverges from

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previous research to make its main contribution. Whereas previous research tends to look at KM as capturing and sharing best practice about a process (Raghu and Vinze, 2007), this paper makes KM part of the process. It differs from previous research, such as Linderman *et al*. (2010), because it is not developing an improved KM capability, that is, in knowledge sharing. Rather, it looks at how knowledge sharing can be embedded into processes necessary to improve the workflow.

CONCEPTUALIZATION

This paper examines how to embed KM into business processes to improve efficiencies in workflow. It differs from previous research on process-centred KM which focused on how knowledge can improve process performance (Raghu and Vinze, 2007) and how process management may improve KM capability, for example, knowledge creation (Linderman *et al*., 2010). This paper focuses instead on how KM can improve business processes. It does this by showing how KM may become part of the process and not a separate OS. By embedding KM into business processes, it identifies and addresses inefficiencies in the workflow. The result is improved knowledge flow within the process. This approach situates KM as a social-constructed reality of work focusing on people rather than technology. It views knowledge as a process rather than a product and, therefore, its management should occur in the act of doing. At this point, the individual develops 'skilful knowing' (Tsoukas, 2003). This approach captures the elements of process-centred KM's view of the operational core of knowledge: workflow execution, information processing, motivation, and decision making (Raghu and Vinze, 2007), within the context of the tasks in performing a business process. KM may improve efficiency within the process by enabling skilful knowing in minimum time.

The conceptual framework emerging from the literature review is presented in Figure 1.

The figure compares the field's contrasting views, summarized in the literature review, about knowledge, KM, and the act of skilful knowing. The framework is used to analyse the case study results which follow. It is used to classify the method for embedding KM into the problem processes. By determining the nature of the knowledge needed, the type of KM required, and the process of becoming a skilful knower, the framework allows the design of process change which will improve the efficiency of the workflow within the process. The design is influenced by classifying the owner of the task in terms of whether it is the responsibility of the individual, the group, or the organization.

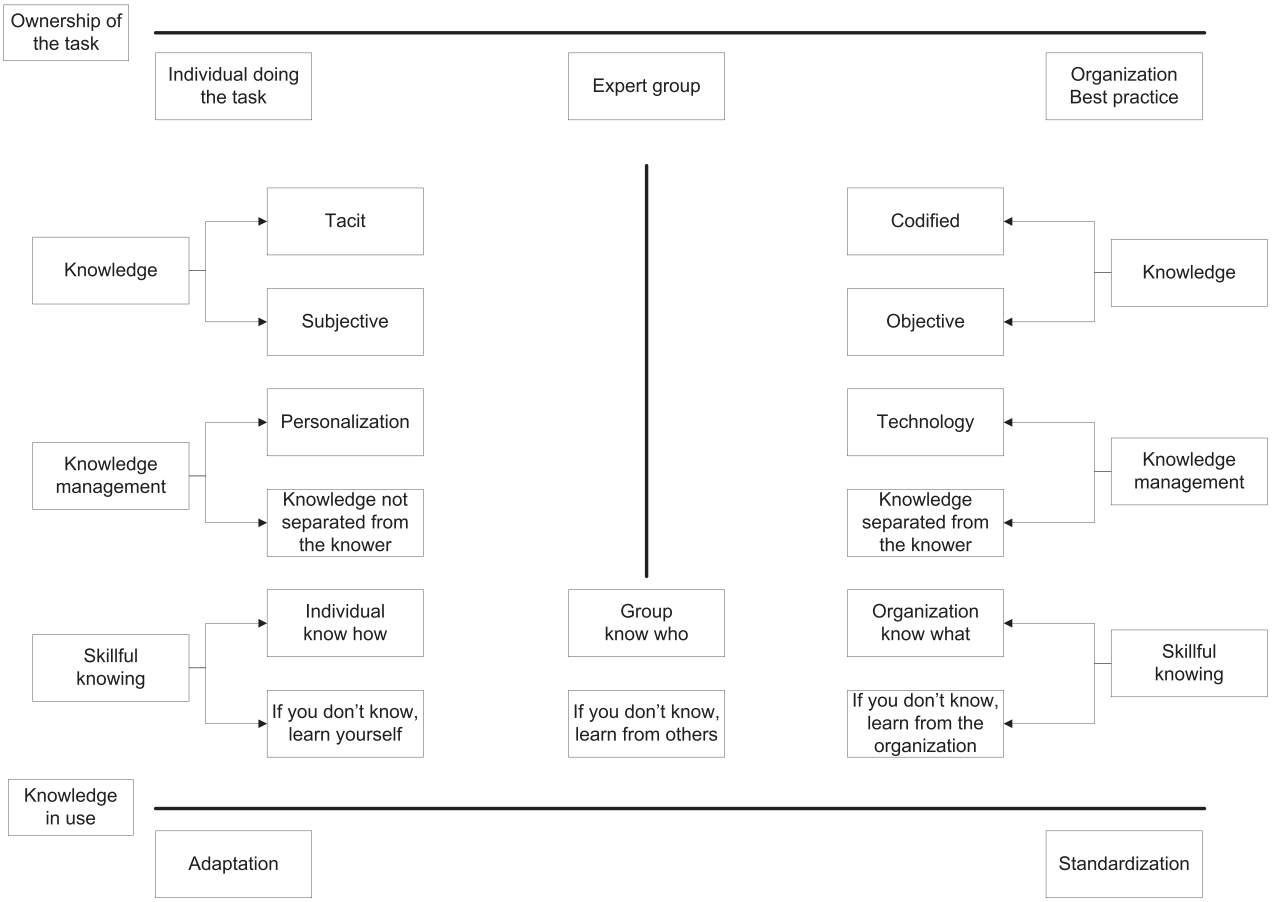

Figure 1 Conceptual frame

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This classification is determined by which should do the newly designed KM task.

RESEARCH METHODS

Action research

This study takes an action research (AR) approach which helps generate insights from field-based case data. AR involves collaboration between researchers and practitioners to enact positive social change and has become widely used as a qualitative research method for the information systems field (Avison *et al*., 2001). AR differs from other qualitative methods such as case study research in that the researcher is directly involved in planned organizational change, both in its design and implementation. This social system may be situated as a community of AR (CAR). A CAR embeds change-oriented projects within a larger community of researchers and practitioners, and sometimes consultants, to produce knowledge that is useful to people in their everyday lives (Senge and Scharmer, 2001, p. 238). The CAR associated with this project was embedded within three distinct OSs representing the way knowledge flowed into, within, and out of the case study organizations. In this way, the capabilities were given context in terms of how they contributed to knowledge flow. The three knowledge flows were as follows:

(a) *External-to-internal*: The flow of knowledge from external partners to the case study organizations (CSOs) and their staff. This is System 1.
(b) *Internal-to-internal*: The flow of knowledge between staff at the CSOs, each CSO treated as a separate organization in their own right. This is System 2.
(c) *Internal-to-external*: The flow of knowledge from CSOs and their staff to external partners—that is, local Saudi industry. Each CSO is again treated separately. This is System 3.

Sampling

The study involved Saudi Arabia's three leading research institutes. It aimed to identify problems associated with knowledge flows between institute staff and external experts and users. All three research institutes provided respondents from four categories: research centre directors, assistant research centre directors (from engineering backgrounds), middle management department heads, and assistant department heads/deans (usually from administrative and management backgrounds). The sample invited individuals with knowledge of internal processes. In total, 13 individuals were invited to participate in this activity. Table 1 is a summary of the interviewees. The respondents were invited to participate in this study, and only one individual did not accept the invitation. Interviews were recording and later transcribed. The respondents were invited to review the transcripts of their interview and validate the context.

In addition to the Saudi research institutes, a leading research university in the USA participated in this study. It was a research-based university that has been placed in the top five in rankings of the world's leading universities in engineering, technology, and physical sciences in 2011 and 2012. It has been providing expert knowledge for a few years to Saudi research institutes and has developed joint ventures with one or more of the institutes in this study. We consider it a typical external knowledge provider. As a global leader in science and engineering research, it was important to understand how experts working at world-class research institutions viewed the institutes' business processes in the context of this study. In this way, we used this external organization to benchmark the processes and identify the capability gap between what is (existing processes) and what should be (ideal processes at world's top five universities). In addition, we identified the business processes shared between the knower and the seeker, uncovering the knowledge flow behaviour in this context. Similarly, a large industry organization in Saudi Arabia participated in this study to explain their experiences with the institutes from a knowledge user perspective.

Data collection

A semi-structured interview questionnaire was designed to collect responses. These questions were framed to capture the core business processes of the organization and represent the majority of the knowledge processes that represent the core capabilities of knowledge workers.

Table 1 Respondent characteristics

	Organization X	Organization Y	Organization Z	External expert	Local industry user
Research director	2	3	–	–	–
Researcher assistant director	1	1	1	–	–
Department head/dean	–	1	–	–	1
Assistant department head/dean	1	–	1	–	–
Scholar	–	–	–	1	–
Total	4	5	2	1	1

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Three interview scripts were developed for three interviewee categories: host organization participants, external expert, and local knowledge user. The interviews were intended primarily to detail the knowledge transfer processes so that we could identify how knowledge flowed within and between core business processes. The numbers of questions posed to participants from case study organizations, external experts, and local knowledge users were 72, 60, and 32 respectively. The questions were constructed with four objectives in mind:

1. to identify as many as possible of the core processes that ran the critical business at the host organizations;
2. to elicit as many as possible of the knowledge processes that existed within the core business processes; and
3. to uncover how knowledge flows behaved within the dynamics of the processes in the preceding texts.

These questions were sourced from relevant literature.

CASE FINDINGS

The framework for presenting the case findings was (i) design the value stream mapping; (ii) identify the location of the waste points; (iii) determine the nature of the waste using lean thinking; and (iv) design KM solutions to embed these into the inefficient business processes.

Value stream mapping

This paper aimed to achieve process management by improving workflow efficiency. The first aspect of the business process context for KM is workflow execution (Raghu and Vinze, 2007). This usually involves coordination costs caused by need for increased communication and information flow, for example, between supervisors and staff. The technical view of KM uses information technology to automate tasks within the process (Raghu and Vinze, 2007) in order to reduce coordination costs. The personalization view of KM adopted by this paper argues the need to consider the knowledge resources necessary for employees to perform these tasks. In order to identify these resources, it is necessary to conduct business process modelling to answer the question: What do employees need to know to do this task well? Having adequate knowledge resources, that is, skilful knowing, will reduce coordination costs.

Value stream mapping (e.g. see Rother and Shook, 2003) enabled effective business process modelling for the case study organizations. The value stream mapping modelling identified several layers of workflow. First, three OSs were identified as the main knowledge flows within the case study organizations (see section on Action Research). Second, work was classified into four capabilities: academic governance, administration, research, and teaching. This is the broad nature of work at universities and academic staff around the world. Third, these capabilities were disaggregated into business processes common to each of the case study organizations. A total of 60 processes were identified.

Identify the location of waste points

Following the principles of process management, the study was a strategic initiative where senior managers defined their vision for change at the case study organizations (Guha *et al*., 1997). The vision was to develop the three Saudi research institutes as world-class organizations. The strategic initiative was to improve the flow of knowledge from external experts to local institute researchers, and then within the institutes, and finally to local industry. The change required was to identify the reasons for the unsatisfactory knowledge flow and to address these problems.

From a process management perspective, the study was planned change involving a fundamental rethinking about how things are carried out at the case study organizations (Hammer and Champy, 1993). A typical first step in planned change is initiation, which involves scanning for organizational problems and opportunities for improvement (Grover *et al*., 1995). This involved the senior managers reviewing their core business processes to consider whether they were operating at optimal capacity. In this review, the managers were asked to consider the nature of knowledge necessary to perform each process. Processes were rated as operating at optimal capacity if the managers perceived that necessary knowledge was either widely known and, therefore, there was no knowledge gap, or it was easily accessible, so individuals could quickly learn what to do. Of the 60 core processes, only 3 (5%) were rated as performing well.

Thirty-three processes (55%) needed some improvement. Twenty-four processes (40%) were rated as needing to significantly improve. These priority processes were major waste points, and knowledge flow was either stuck or slowed to a level causing workflow inefficiencies. The problem processes were spread fairly evenly across the three OSs: 9 of these processes (38%) related to the internal to external OS, 8 processes (33%) involved the external to internal OS, and 7 processes (29%) involved the internal to internal OS.

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Determine the nature of the waste using lean thinking

Lean thinking was applied to the 57 processes identified as being less than optimal. An overall analysis of these processes is presented before 10 of the 24 priority processes are examined in more detail. The types of waste are listed in the succeeding texts in terms of their proportion of the 57 processes:

- rework (defects and correcting): 22 processes (39%);
- waiting (approvals): 11 processes (19%);
- underutilized people: 9 processes (16%);
- transportation: 7 processes (12%);
- inventory (waiting due to batching): 3 processes (5%);
- overproduction: 3 processes (5%);
- motion: 1 process (2%); and
- over processing: 1 process (2%).

The main type of waste is reworking largely caused by employees having incorrect or incomplete knowledge about how to perform a task within the process. Shingo and Dillon (1989) see reworking as a waste because it produces defective products or work below the established quality standard. This means that researchers at the case study organizations were doing work incorrectly, making mistakes, and producing work outputs of low quality because they lacked knowledge about the process. This also caused high agency costs (e.g. see Huizing and Bouman, 2002) as supervisors, or other employees were required to correct unsatisfactory work.

The next main type of waste was related to time, that is, waiting for approvals. Shingo and Dillon (1989) see waiting as a waste because it is lost productivity in the time interval in which no task or operation is executed. Loss from waiting occurs when the employee needs to remain within the work process in order to complete the task. Lost productivity occurs when the employee is unable to perform other work while being delayed within the process. Examples at the case study organizations were when employees were forced to repeat requests for clarification or other help or to seek multiple alternatives.

Other significant types of waste included underutilized people and transportation. Underutilized people occurred largely due to experienced researchers being unable or unwilling to share their knowledge with less experienced researchers. Waste occurs because less experienced researchers spend time seeking help which is not given and then learning something that is already known, that is, reinvent the wheel. Transportation is akin to waiting in a queue. Waste points are created due to attitudinal factors. Decision makers see the knowledge surrounding the process as difficult and, therefore, defer making decisions, or they do not see the benefit to be gained from resolving the issue. Shingo and Dillon (1989) see transportation as a waste because it does not add value and only adds cost. It is a measure of non-productive time including inefficient learning, organizing others, persuading cooperation, and communicating value. The following section analyses result in more detail by looking at the nature of the waste in 10 priority processes.

Applying the conceptual framework

Process management aims to improve performance by designing or redesigning processes (e.g. see Silver, 2004). This paper uses lean thinking to identify inefficiencies in workflow. These are tasks within processes which have waste caused by unskilful knowing. This paper's conceptual framework (Figure 1) enables examination of the nature of this waste. The following analysis classifies the case study organizations' priority processes, that is, those with the most need for improvement, in terms of who has main ownership of the problem task: the individual, group, or organization. Ownership is determined by the nature of the knowledge necessary to achieve skilful knowing. This paper's process-centred KM involves designing or redesigning tasks within these priority processes to enable skilful knowing. KM is embedded into the processes as the new or redesigned task. Performance improvement occurs via increased workflow execution (e.g. see Raghu and Vinze, 2007).

Individual

These processes are owned by the individual (see left hand side of Figure 1). This means that skilful knowing occurs by the individual in the act of performing tasks within the process. This knowledge is tacit and subjective. Knowledge is not separated from the knower. The outcome of skilful knowing is individual know-how. It requires the individual to work out the best solution themselves. This recognizes that there are multiple best solutions, and the process enables this multiplicity due to its context-sensitive nature. The waste exists because the individual is unable to work out the solution themselves or this is carried out inefficiently, that is, slowly. KM may be embedded in the process by enabling the individual to adapt the task to fit their context. Three of the processes that considered priorities are used to illustrate.

The first process was 'researcher attributes' which was part of the internal to internal OS and research capability. This was defined as the capability of research staff to share knowledge. Some respondents felt that sharing knowledge across disciplines was an essential part of being a researcher, as illustrated by these quotes:

DOI: 10.1002/kpm

As you know, if I'm a geophysicist and if I want to build a system, then I need electrical engineers, electrical communication engineers, because this is not my field. For that reason we join with other people to help us in some steps.

It's not only useful, it's a must. In research, there's no way you can do research on your own nowadays. You cannot find one single successful professor without global collaboration and multidiscipline collaboration. We need nowadays a multidisciplinary collaboration; we need something from computer background, in mathematical, biology, chemistry. In our field, we are seven different divisions. We run several samples from different areas of collaborations. This is a must.

There are efforts that cannot be achieved on an individual level.

These comments focus on the need to collaborate, particularly if the researcher needs knowledge they do not have, such as from another discipline. The respondents also recognized that it was difficult to share knowledge across disciplines due to its complexity as a task. The following quotes illustrate:

Researchers find little synergy to deal with complex engineering problems due to non-availability of a multidisciplinary team. They have difficulty finding overseas experts when they realize that a niche area expert is not available.

One of the real barriers to knowledge sharing is the multidisciplinary nature of the knowledge to be transferred. Multiple disciplinary requirements demand involvement of teams or groups, which mean more management and logistical skills and resources. It is extremely difficult to transfer complex knowledge using only one individual.

These quotes explain that cross-disciplinary research collaboration is difficult due to the coordination costs of organizing teams and finding suitable experts. It is made even more difficult by motivational problems, that is, whether individuals are willing to learn or share, as illustrated by this quote:

I have people here that have been experts for around 30 years. But he is an expert in one particular subject. If you want him to open a new dimension, you will always feel he is hesitant, and he doesn't want to really go there.

These problems combined to cause waste in research collaboration across disciplines. This led to unsatisfactory performance, as illustrated by this quote:

Many opt to give up without anyone knowing. They would just pass through the project to reach an end, and get over with it.

These problems combined to cause waste in cross-disciplinary research. This led to unsatisfactory performance because knowledge was not being shared across disciplines. The process was ineffective because staff were doing it incorrectly. This occurred because staff did not know what to do when faced with problems associated with cross-disciplinary knowledge sharing. They also did not learn how to resolve these issues for future research projects, leading to continual ongoing inefficiencies in this process. This is classified as an individual task because research collaboration is a multifaceted activity and a solution varies by context and discipline.

The second process was 'training junior researchers', which was part of the internal to internal OS and teaching capability. This was defined as teaching individual researchers how to research. The following quote shows how this was carried out haphazardly based on multiple self-interests:

To find ideas or to start up ideas, there are different ways for doing that. The ones that I know of is that you start up with a problem and you try to search for a solution, for a way to resolving the problem… The unique thing about it is really listening to the people who are having the problem. Lots of times the research here is basically, people who are trying to do research conduct based on their own interests, not the need or a given problem.

The comments reveal that waste points are created because researchers tend to design research in an ad hoc fashion, based on self-interest, while not searching for needs of 'the real world' or local industry. This experienced researcher has learned that this ad hoc self-interested approach is ineffective. His approach to designing research is based on practical needs and is an example of how senior staff could train junior researchers. The experience gathered by this senior researcher may be lost to the organization if he exits the organization without sharing it or he refuses to share.

These problems combined to cause waste in researcher training. This led to unsatisfactory performance because the experience of senior researchers was not being adequately shared with others. The process was ineffective because the staff were doing it incorrectly. This occurred because the junior staff did not follow the experience of the senior staff and instead followed their own self-interest. This is classified as an individual task because the nature of research design is an individual's choice and allowing the academic freedom to make this choice is good practice. However, this choice could be improved by sharing the experience of the senior researchers.

The third process was 'train industry' which was part of the internal to external OS and the capability teaching. This was defined as industry staff working with researchers on campus. The staff felt that this process was ineffective because of confusion about the role of the research institutes, as illustrated by this quote:

We are talking about companies. Companies need performance. Performance needs skilled professionals. If we cannot perform outside in the industry then we cannot compete as

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they can. I mean, if we cannot have the same resources as our competitors, then we cannot perform. We don't have the knowledge.

Although the case study organizations are non-profit governmental bodies, the respondents felt that they position themselves to local industry as profit-oriented. As a consequence, case study organizations were unwilling to share experience and knowledge with local industries unless they were paid for their knowledge. However, local industry did not value the knowledge of the local researchers, as illustrated by this quote:

You cannot deny that. You cannot compare the outcome coming from us or other local universities with research outcomes coming out from MIT or Stanford, or Cambridge or those guys. The positions of these universities is different so, naturally the results and the competencies they have is different and for those industrial firms like ARAMCO and SABIC, who have the money, they can request any experienced house to do the research for them. So, it is an open market.

These problems combined to cause waste in research partnerships. This led to unsatisfactory performance because knowledge was not being used by local industry and there was little commercial research income. The process was ineffective because the staff were doing it incorrectly. This occurred because local industry did not see the value of the knowledge of local researchers. Local industry perceived local researchers as less competitive compared with overseas researchers or consultants. Until this barrier was overcome, this process could not work. This is classified as an individual task because the value of research varies by context and discipline and is best explained by the individual subject matter expert. However, the staff could receive training to prepare them for these negotiations.

Group

These processes are owned by the group (see middle of Figure 1). This means that skilful knowing occurs by the group in the act of performing tasks within the process. This knowledge is social tacit and more subjective than objective. Knowledge may or may not be separated from the knower. The outcome of skilful knowing is group know-who. It requires the individual to learn from others. This recognizes that there is more than one best solution, but the group is best placed to decide on these solutions. It allows for multiple contexts and multiple expert groups. The waste exists because the individual is unable to access the group's knowledge or the group is unable to find a solution. KM may be embedded in the process by enabling the individual to access the group's solution or to help the group find a solution. Two of the processes that considered priorities are used to illustrate.

The first process was 'national coordination' which was part of the external to internal OS and the capability academic governance. This was defined as the work of the government to coordinate external partnerships for the case study organizations. The following quote suggests that this was poorly managed:

The problem is that there is no national agency responsible to coordinate for this task [external-internal knowledge sharing]. More importantly, there is no national agency qualified to do this kind of job… Saudi Arabia should have a ministry for scientific research like many other countries in the world. All national research institutions, whether governmental, private, or part of universities would report to this ministry. If a ministry was present, then complete databases would be made available, updated, and it would be checking after research activities, controlling the progress of research on a national scale and so on.

The respondent is explaining that there is no government control of the first OS, external to internal knowledge flows, which means that priorities cannot be set at a national level nor progress monitored.

These problems combined to cause waste in research strategy. This led to unsatisfactory performance because relationships with other universities were not coordinated. The process was ineffective because the staff were doing it incorrectly. This occurred because the staff were not forming relationships based on the country's research needs. This is classified as a group task because senior government officials would need to work with stakeholders, including universities and industry, to develop a national strategy. This also surfaces the aspirational aspects of the respondent's comments, that is, 'like many other countries'. This was a frustration common to many respondents who felt that Saudi Arabia needed to follow best practice at leading global universities. This suggests that the group should consult with other universities to learn how this may be carried out.

The second process was 'executive attributes' which was part of the external to internal OS and the capability administration. This was defined as the skills to identify and capture opportunities regarding external knowledge. The following quote explains how overseas universities typically build relationships with local industry:

I met with a Korean expert. This expert worked for Samsung and had experience with doing research with industry. He said they started by bringing American experts to their organization, and they paid them US$150,000 and US $160,000 in salaries. Then things and developments start emerging once you begin this way. We, at this stage, will go into basic car performance research in some shallow areas and cooperate with Ford company for instance to sell some patents that we can actually develop. Once we do some

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work, we can sell to them. Like what goes in Germany. An engineering school in a university advances a new engineering technology and then sells it to Mercedes. They get paid for that and in this way, they fund their research. That is a good start. Back to Samsung, they began to bring those experts from the US and they made their visa processing and all related logistics very smooth to an extent that they didn't feel any noticeable struggle. The next step is to send those nationals who gained good experience from those experts to go and work at Ford, for example, for free, on the cost of the hosting organization here in Saudi Arabia. Ford will be getting trained engineers for free, its benefitting for them. A win-win scenario. For two years, they work for you and then come back.

These problems combined to cause waste in research collaborations. This led to unsatisfactory performance because relationships with industry were not generating sufficient value either commercially or in terms of knowledge transfer. The process was ineffective because the staff were doing it incorrectly. In follow-up questioning, the respondent explained that the way the staff formed relationships with industry was 'disorganized'. This respondent had learned how to do this, that is, best practice, from working with external researchers. However, other staff were left to learn how to do this on their own. This is classified as a group task because senior researchers with similar exposure to external best practice should work together to develop a solution, but it also recognizes that there may be multiple groups due to different industry or discipline contexts, each with different solutions.

Organization

These processes are owned by the organization (see right hand side of Figure 1). This means that skilful knowing occurs by the organization in the act of performing tasks within the process. This knowledge is codified and objective. Knowledge is separated from the knower. The outcome of skilful knowing is organizational know-what. It requires the individual to learn from their organization. This recognizes that there is one best solution, and the same process may be applied across any context. The waste exists because the individual is unable to access organizational knowledge or it does not yet exist. KM may be embedded in the process by enabling the individual to access the standardized knowledge, for example, the best practice. Five of the processes that considered priorities are used to illustrate.

The first process was 'knowledge-sharing metrics' which was part of the external to internal OS and the capability academic governance. This was defined as measurements of knowledge activity between external experts and local researchers. Effective process management requires metrics to be designed, communicated, and audited (Kaplan and Norton, 1996). The following quote illustrates how the case study organizations measured knowledge sharing:

We are measuring progress in terms of knowledge use and sharing by the number of papers that we publish, by the number of people who are doing research, or capable of doing research and by the services that we perform for, for example, for companies. Knowledge sharing is to have common research between you and others externally. We currently have this, yes, but I think not up to the standard. Well, we have it as part of our key performance indicators but we measure it in different ways like joint supervisions, joint projects, but I mean the measure itself, how to measure transfer of knowledge, I would be happy to find a way to measure it in a very precise way.

These problems combined to cause waste in research performance measurement. This led to unsatisfactory performance because it measured the wrong thing, that is, work outcomes rather than knowledge-sharing activity, which meant that behaviour did not align with strategy. The process was ineffective because the process was wrong. There are many factors that contribute towards research outputs such as publications. This may be resolved by matching lead indicators (activity) to lag indicators (outputs). This is classified as an organizational task because it is able to be quantified and standardized across any university and discipline.

The second process was 'research leadership' which was part of the internal to internal OS and the capability research. This was defined as activities necessary to facilitate knowledge sharing between staff. The following quote illustrates how the staff felt that leaders could not enforce knowledge sharing because there were no consequences:

We have a problem with the system. While the system it does sometimes reward, it doesn't punish enough so that people perform at their most.

While this quote illustrates how research leaders lacked motivation to share their knowledge:

So basically, a researcher here instead of having a professional team, he usually ends up with a team who needs to be raised in terms of skills. Most researchers here are becoming discouraged because of the time, because they noticed that the time they spend on developing skillful people, most of it goes away, because those skilled people move on.

These problems combined to cause waste in research leadership. This led to unsatisfactory performance because research behaviour was not being managed. The process was ineffective because the process was wrong. These comments show how organizational culture created a situation where research leadership could see no benefits or costs in encouraging knowledge sharing. This is classified as an organizational task because it requires change to organizational culture, and this may be expressed

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through norms and values and measures of benefits and costs.

The third process was 'regulation of external partnerships' which was part of the internal to external OS and the capability academic governance. This was defined as leadership of partnerships with local industry. The following quote illustrates how there was a misalignment between the goals of researchers and local industry:

> *With regards to the biggest local industrial partners, are they really research oriented from a mindset perspective to finding new technologies? You can say all our factories are operations oriented. The smaller industries are owned by big businessmen who are looking for quick revenues, and they are far away from this subject. They are not looking for what you call long-term investments. Even if they have 5 or 6 guys, shuffling papers, the real people are outside. The other point is that it is not easy to penetrate and have good communication and interaction with them. You can see little initiatives here and we don't know if there is what you call kingdom wide teamwork.*

These problems combined to cause waste in research partnerships. This led to unsatisfactory performance because research was not being used by local industry. The process was ineffective because the process was wrong. Two problems emerged. First, local industry felt that the case study organizations needed to contribute to national benefit by embracing their responsibility to improve the quality and image of local engineering research and related industries. Second, the internal-to-external knowledge flow was traditionally financially driven. The local industry must pay the case study organizations for collaboration to occur. These two issues created waste points in the knowledge flow necessary for case study organizations to attract industry partners. Researchers wanted the industry to help them by providing access to research data, whereas the industry wanted researchers to help them build their capability. This was another misalignment between researchers and industry. The issue of payment was about relational versus transaction-based collaboration between staff and industry. The respondents felt that the case study organizations should focus on establishing the research relationship rather than financial gain. They felt that without this relationship, local industry would ignore them and prefer to work with overseas experts. However, local industry did not seek a relationship with academic staff; they preferred a transaction-based collaboration, that is, commercial research, with a focus on return on investment rather than advancement of knowledge. This is classified as an organizational task because the focal task is improved relationship management. This is able to be standardized as best practice and followed by training staff working with local industry.

The fourth process was 'knowledge-sharing agent' which was part of the external to internal OS and the capability academic governance. This was defined as identifying external research partners and negotiating contracts. It is an individual, either external or internal, who acts as a liaison between external knowers and internal knowledge seekers. The following quote illustrates how management felt this was a normal part of the role of academic staff:

> *At [Organization Y], we believe that the researcher or the project manager, who is dealing with an external expert or the local industry from our side, is the responsible person to watch out for knowledge transfer.*

These problems combined to cause waste in research collaborations. This led to unsatisfactory performance because the activity was being delegated to the individual. The process was ineffective because it was not being carried out. While management expected staff to do this role, it was not being carried out because there were no policies to guide staff on how to carry out such a task and most staff did not want to do it. On the first point about lack of policies, many academic staff lack the skills to identify and negotiate with external experts. While it might be assumed that researchers develop such contacts as a normal part of work, for example, via research collaborations or attending conferences, that does not mean that this is always performed well. Many academic staff prefer to work on their own or lack the ability to build international networks. This is classified as an organizational task because it requires policies and training on best practice, as well as reward and recognition incentives.

The fifth process was 'knowledge broker' which was part of the internal to internal OS and the capability academic governance. This was a similar role as the knowledge agent, except it was an internal staff member who acts as a liaison between internal knowers and internal knowledge seekers. There were two main problems with this expectation from management about staff being knowledge brokers: (i) accepting responsibility and (ii) knowledge hoarding.

On the first point about accepting responsibility, the following quote illustrates how the respondents felt that knowledge sharing needed to become a formal job requirement:

> *If you want to ask someone to give out knowledge to others and you don't have this task in your job description… I don't have this job description in my job. When I talk to that person to give a lecture to us, I communicate with him as a researcher. There is nothing I have to support me so I can't be effective in this coordination task or as knowledge transfer officer. If something like this is behind my name then it will give me power to communicate. The job description is very important.*

On the second point about knowledge hoarding, the following quote illustrates how the staff felt that

DOI: 10.1002/kpm

the case study organizations' organizational culture would not support this role:

> *If you have a knowledge transfer specialist to coordinate knowledge, he might not coordinate knowledge, he might cut knowledge when it is going outside or inside. If I understand the work of the specialist correctly, those specialists will be some sort of guards at the end, that will be like, ok, say this, don't say this, which is obviously not acceptable.*

These problems combined to cause waste in research connectivity. This led to unsatisfactory performance because knowledge was not being shared. The process was ineffective because it was not required to be carried out; that is, it was voluntary. Giving a staff member power to coordinate internal knowledge flows may actually increase waste because they become a barrier or blockage in knowledge flows, rather than a facilitator, due to knowledge hoarding or acting as a gatekeeper. This requires careful selection of staff with positive behaviours such as team work, cooperation, and collaboration skills. The comments suggest a need for job redesign to make knowledge sharing recognized as part of the job. The failure to do so caused confusion and uncertainty amongst staff about what was expected of them in terms of knowledge sharing. It might be assumed that academic staff are required to share knowledge by definition of their role. However, as may be seen from the comments, the case study organizations could improve in this area. Universities, like any organization with knowledge workers, have heterogenous capability, which is reflected in performance scorecards such as university rankings. The comments reflect that academic staff also varied in their knowledge-sharing capability. This is classified as an organizational task because it may be addressed by introducing best practice via job redesign.

Design knowledge management solutions to embed these into the inefficient business processes

Following the principles of process management, this section explores how KM might be embedded within business processes to achieve breakthrough improvements in performance (Grover *et al*., 1995). The strategic change required was to reduce or eliminate inefficiencies in workflow caused by waste points in business processes. The waste points were tasks within problem processes which caused knowledge flow to slow or even stop. The outcomes desired of this process change were performance gains in improved processes (Guha *et al*., 1997).

This paper aimed to show that embedding KM within problem processes would enable individuals to move from being unskilful knowers to skilful knowers. Figure 1 presented a framework for identifying the cause of the workflow inefficiency, that is, why staff were unskilful knowers. This section explains the KM solutions embedded as new tasks to achieve process improvement. They become part of the routine in a new improved way of doing the process (Linderman *et al*., 2010). KM embedded into problem processes creates skilful knowing.

Table 2 summarizes the method used to embed KM into the priority processes discussed in the preceding texts. The columns on the left-hand side of the table, under the section process management, summarize the results in the preceding texts. The columns on the right side present the results of applying KM to these processes. The first column in this section of the table is the epistemology of the knowledge associated with the process problem, classified in terms of whether it is objective, that is, an object independent of human perception, or subjective, that is, it is personal and context-sensitive (Sabherwal and Becerra-Fernandez, 2003). The second column is ontology, which is whether the ownership of the knowledge lies at the individual, group, or organizational levels (Sabherwal and Becerra-Fernandez, 2003). The third column is knowledge type in terms of know-what, that is, reading codified knowledge about the task such as a policy is sufficient, or know-how, that is, may require practice or discussion (Edmondson *et al*., 2003). The fourth column is the KM process of creating, storing, retrieving, transferring, and applying knowledge (Mousavizadeh *et al*., 2015), classified here in terms of how skilful knowing is most effectively carried out for this task. The fifth column is the KM task. This is the solution to improve performance within the problem process and eliminate the waste point in the workflow. The sixth column describes how the KM is embedded into the relevant business process. The processes have been redesigned to describe the workflow in terms of best practice. This is illustrated by the names of the processes in this column. For example, the first process listed in the table—knowledge-sharing metrics—is now a task within a new process called research partnerships. This captures the nature of the workflow associated with this process and avoids describing processes in terms of KM, that is, knowledge-sharing partnerships. The measurement becomes part of the process rather than the process itself. In this way, it focuses on the value created from the process which is to build and maintain strong relationships with external research partners. KM is embedded within this task.

DISCUSSION

There are several findings. First, the need for process management was clearly demonstrated. A typical first step in planned change is initiation, which involves scanning for organizational problems and opportunities for improvement (Grover

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Table 2 Embedding knowledge management into problem processes

	Process management					Knowledge management					
Process	Description	Organizational system	Capability	Nature of waste	Problem	Epistemology	Ontology	Knowledge type	Knowledge management system	Knowledge management task	Embedding
Knowledge-sharing metrics	Measurements of knowledge activity between external experts and local researchers	External to internal	Academic governance	Reworking (defects)	Match lead and lag indicators of knowledge sharing	Objective	Organizational	Know-what	Retrieving	Design measures of sharing activity	Task within research partnerships
Knowledge-sharing agent	A person(s) to identify external research partners and negotiate contracts	External to internal	Academic governance	Reworking (defects)	Policy guidelines, motivation	Objective	Organizational	Know-what	Applying	Job redesign	Task within research partnerships
Research leadership	Activities necessary to facilitate knowledge sharing between staff	Internal to internal	Research	Reworking (defects)	Reward sharing behaviour and punish non-compliance	Objective	Organizational	Know-what	Sharing	Design reward and recognition, disciplinary action	Task within performance appraisal
Knowledge brokers	Having formal roles for staff, making them responsible for knowledge sharing, particularly those staff who have access to external experts	Internal to internal	Academic governance	Reworking (defects)	Accept responsibility, knowledge hoarding	Objective	Organizational	Know-what	Applying	Job redesign	Task within academic staff job description
National coordination	The work of a ministry of	External to internal	Academic governance	Waiting (approvals)	Government strategy	Subjective	Group	Know-who	Sharing	Community of practice	

(*Continues*)

DOI: 10.1002/kpm

Table 2 (*Continued*)

	Process management					Knowledge management					
Process	Description	Organizational system	Capability	Nature of waste	Problem	Epistemology	Ontology	Knowledge type	Knowledge management system	Knowledge management task	Embedding
	education to coordinate external partnerships for the case study organizations										Task within strategic planning
Executive attributes	The skills to identify and capture opportunities regarding external knowledge	External to internal	Adminis-tration	Waiting (approvals)	Negotiating secondment with industry	Subjective	Group	Know-who	Sharing	Relationship management	Task within research commercial-ization
Regulation of external partnerships	Leadership of partnerships with local industry	Internal to internal	Academic governance	Waiting (approvals)	Confused value proposition	Objective	Organizational	Know-what	Sharing	Relationship management	Task within research commercial-ization
Researcher attributes	The capability of research staff to share knowledge	Internal to internal	Research	Underutilized people	Finding an expert, project management across disciplines, willingness to participate	Subjective	Individual	Know-how	Storage	Competency mapping	Task within career development
Train junior researchers	Teaching individual researchers how to research	Internal to internal	Teaching	Underutilized people	Self-interest, not focusing on need	Subjective	Individual	Know-how	Sharing	Experience curve acceleration	Task within research management
Train industry	Industry staff working with researchers on campus	Internal to external	Teaching	Underutilized people	Researcher knowledge undervalued by industry	Subjective	Individual	Know-how	Sharing	Learning curve acceleration	Task within community engagement

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et al., 1995). Of the 60 core processes, only 3 (5%) were rated as performing well. Twenty-four processes (40%) were rated as needing to significantly improve. Second, the cause of unsatisfactory performance was identified. The main type of waste was reworking largely caused by employees having incorrect or incomplete knowledge about how to perform a task within the process. The next main type of waste was related to time, that is, waiting for approvals, which is non-productive time because the employee is idle until allowed to move to the next step in the process. Other significant types of waste included underutilized people and transportation. Underutilized people occurred largely due to experienced researchers being unable or unwilling to share their knowledge with less experienced researchers. Transportation is a measure of non-productive time due to inefficient learning, organizing others, persuading cooperation, and communicating value.

Third, this paper's conceptual framework (Figure 1) was applied to examine why there was unskilful knowing within the process. Ten of the priority processes were examined in detail. The 10 processes were classified in terms of who has main ownership of the problem task: the individual, group, or organization. Ownership is determined by the nature of the knowledge necessary to achieve skilful knowing. The three levels are now discussed.

At the individual level, unskilful knowing caused waste in researcher training, cross-disciplinary research, and research partnerships. This led to unsatisfactory performance because experience was not being shared (senior and junior researchers), synergy was not being created (between disciplines), and there was little commercial research income (partnerships). The processes were ineffective because staff were doing it incorrectly. This occurred because the staff followed their own self-interest in their research strategy and made errors in judgment, the staff did not try to resolve access and coordination problems across disciplines as they were seen as too difficult, and the staff could not explain the value of their research to local industry. These processes require individual-level solutions because they are multi-faceted activities and the solution varies by context and discipline. Skilful knowing occurs in the act of doing, and the individual must learn how to do deal with these problem tasks themselves. KM can help them learn these skills.

At the group level, unskilful knowing caused waste in research strategy and research collaborations. This led to unsatisfactory performance because relationships with other universities were not being coordinated (strategy) and relationships with industry were not generating sufficient value (collaborations). The processes were ineffective because the staff were doing it incorrectly. This occurred because the staff did not form relationships with other universities based on the country's research needs and relationships with industry were 'disorganized'. These processes require group-level solutions because government officials and senior researchers would need to work with stakeholders, including other universities and industry, to develop strategies. Skilful knowing occurs in the group's act of doing; the task is too complex for any individual to solve on their own, and the individual must learn by working with others how to develop solutions to the problem tasks. KM can help them learn these skills.

At the organizational level, unskilful knowing caused waste in researcher performance measurement, research leadership, research partnerships, research collaborations, and research connectivity. This led to unsatisfactory performance because behaviour did not align with strategy (measurement), behaviour was not being managed (leadership), research was not being used by local industry (partnerships), the activity was being delegated to the individual (collaborations), and knowledge was not being shared (connectivity). The processes were ineffective because the process itself was wrong (measurement, partnerships, and leadership) or the process was being carried out incorrectly (collaborations) or was not required to be carried out; that is, it was voluntary (connectivity). This occurred due to cognitive blind spots which caused misunderstandings and confusion about the task. A common theme was inability to grasp the real nature of work associated with managing academic staff, which meant that important behaviours were not being managed:

- Measurement focused on outputs (publications) rather than inputs (sharing).
- Leadership allowed an organizational culture which failed to recognize benefits or punish costs associated with knowledge sharing.
- Partnerships misunderstood that local industry did not seek a relationship with academic staff; they preferred a transaction-based collaboration, that is, commercial research, with a focus on return-on-investment rather than advancement of knowledge.
- Collaborations assumed that individuals will do this naturally; however, many academic staff prefer to work on their own or lack the ability to build international networks.
- Connectivity failed to address the reality of knowledge-sharing barriers such as power, trust, motivation, gatekeepers, and hoarders.

These processes require organizational-level solutions because they may be addressed by introducing policies and training on best practice, as well as organization-wide process management (e.g. change management). Skilful knowing occurs from standardizing the act of doing (e.g. best practice), and the individual must learn from their organization how to do these problem tasks. KM can help the organization learn these skills.

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Further conclusions may be drawn about the inefficiencies in the workflow from the discussion in the preceding texts. The nature of the waste causing waiting (approvals) is mainly related to leadership. There are numerous research on the importance of leadership in successful process management. Whereas traditional views on business process reengineering as change management see leadership as critical management support, process-centred KM views leaders as designing organizational culture and structure which enables effective KM (Linderman *et al*., 2010). The results from the case study organizations also introduced complexities caused by national culture. The location of the study, Saudi Arabia, has a national culture which is different from western culture. The transfer of knowledge from external experts, usually from the west, needs to take these differences in national culture into account. The leadership issues at the case study organizations emerged in two ways. First, at the country level, researchers felt constrained by political sensitivities. Second, at the institute level, hierarchy created barriers between researchers. There were problems in terms of relationships and communication. National culture, therefore, seems to have created waste points in the flow of ideas between the government and the institute senior managers and between senior managers and their staff.

There was frustration from the respondents about the lack of direction from leaders in the problem processes. The aspirational nature of the comments highlights that researchers were aware of best practice from their exposure with overseas universities. Their frustration emerged from feeling that they knew what to do but leaders were either unaware or were unwilling to act. The workflow inefficiencies were caused by researchers pursuing the direction they needed without success and time spent developing their own process. The need for change was caused by lack of an existing process at the organizational level and multiple different processes at the individual level as researchers developing their own way.

Both leaders and staff sometimes lacked the tacit knowledge necessary to perform the tasks within the process at a satisfactory level. This is process-instance knowledge (Jung *et al*., 2007). The staff at the case study organizations did not know the value of a task within the process or when to perform it. This created 'blind spots' where the staff working within a process were unaware of how a task might improve performance or its environmental context, that is, the trigger indicating when to do it. The nature of the waste caused by underutilized people is related to incompetence. The staff were unaware of how to do a task within a process. This is process-related knowledge which means the type of knowledge which can be used by activity performers when a business process is actually executed (Jung *et al*., 2007). It emerged in two main ways at the case study organizations: first, staff being unable or unwilling to share knowledge within cross-disciplinary teams, and second, staff being unable to persuade local industry that their knowledge has value.

CONCLUSIONS

The management of organizational knowledge as a source of competitive advantage has been acknowledged by the process management field (e.g. see Linderman *et al*., 2010). Operations management researchers have recognized the importance of knowledge in process improvement (Choo *et al*., 2007). This paper focused on how KM can improve business processes. It proposes a view of process-centred KM driven by the individual in the act of doing. The personalization view of KM aims to increase efficiency by reducing time spent accessing necessary knowledge about the tasks within the process via information systems, social capital, or learning by doing. At this point, the individual develops 'skilful knowing' (Tsoukas, 2003). This approach captures the elements of process-centred KM's view of the operational core of knowledge: workflow execution, information processing, motivation, and decision making (Raghu and Vinze, 2007), within the context of the tasks in performing a business process. KM may improve efficiency within the process by enabling skilful knowing in minimum time.

This paper used lean thinking to explore how skilful knowing will reduce or eliminate waste and increase efficiency in workflow. It assumes that unskilful knowing creates waste because the individual lacks know-what or know-how knowledge (e.g. see Edmondson *et al*., 2003), and this causes delays. The activity of moving from unskilful knowing to skilful knowing in the act of doing is controversial. The technology view of KM proposes that the unskilful individual will use information technology to identify and then use knowledge which has been captured by their organization to help them become skilful (e.g. see Kearns and Lederer, 2003). The personalization view of KM proposes that this individual will work it out for themselves, that is, learn by doing, or seek help from others (Gardner, 2012).

This paper presented knowledge as skilful knowing, and this occurs at the individual, group, and organizational levels. How the organization manages skilful knowing at these three levels is determined by its KM. The paper set out to examine how KM may be used to achieve business process improvement by embedding KM within problem processes. In achieving this aim, the paper applied lean thinking principles to identify inefficiencies in workflow and knowledge flow, which we call waste points. It then applied KM principles to identify why these

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waste points existed and to surface solutions. We then embedded KM into the problem processes to remove the waste points, allow knowledge to flow, and improve the efficiency of workflow.

Whereas previous research tends to look at KM as capturing and sharing best practice about a process (Raghu and Vinze, 2007), this paper makes KM part of the process. It embeds KM as one of the processes routines so it becomes part of the best practice. It does this by situating KM within the individual's activity of performing the process at work.

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