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PRACTICAL APPLICATION OF A KNOWLEDGE DEVELOPMENT LIFE CYCLE

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We describe the practical application of a reflective knowledge development lifecycle (KDLC) designed to be used by organisations reviewing their KM processes and capability. A Knowledge Development Life Cycle model, together with knowledge representation and visualisation tools, was used by an environmental scientist to find gaps in processes and design in implementing an organisation-wide research framework. Analysis showed that the organisation was strong in areas including decision-making, document creation and archiving, and understanding operational needs. Underperformance was revealed in other areas, notably communication between various organisational sections and in responsibility for the chain of custody of operational documents. Developing a knowledge repository for the project also highlighted the research framework's inherent complexity among people, resources, research activities, operational tasks and communication outcomes. Our case study has helped to validate the utility of the KDLC in ensuring alignment of organisational processes and strategy following a disruption to its traditional role.

Key Words: knowledge development life cycle; case study; adaptive management; organisational change and review; Box-Ironbark ecological thinning; Protégé

1. Introduction

In previous work (D. J. Pigott, Hobbs, & Gammack, 2006) we introduced a knowledge development life cycle (KDLC) designed to be applicable to organisations reviewing their knowledge management processes and capability. Such reviews are required both in response to disruptive external events (such as Y2K, mergers or new compliance requirements), and more generally to ensure alignment of relevant organisational systems and processes with purpose and strategy. In large organisations knowledge management activities may be piecemeal or patchy and a higher order analysis is needed to integrate these effectively.

The lifecycle design involved feedback loops, paths and checkpoints to manage this review process reflectively on a consciously prepared and ongoing basis, and those details are briefly recapitulated in section 2 below. Whilst referenced to perceived deficiencies of knowledge lifecycles in extant literature, the theoretical content of our design had largely emerged from categories found useful in the practical work of preparing several organisations' data and KM strategies, and from subsequent knowledge management activities in organisational settings. The resulting KDLC however had not yet been tested as a whole, motivating applied research in a suitable environment to develop a case study.

The purpose of the present paper is to apply the theory directly in a practical setting, namely a large organisation which was at a critical point in time, and which needed to reflectively and critically investigate and stabilise its knowledge management practices and systems.

Our instrumental case study is intended to illustrate the KDLC's components and to help refine and modify our understanding of the KDLC in action. The chosen research, (which we describe in more detail presently) involved finding the gaps in organisational processes and project design for the documentation and implementation of a large-scale environmental management research framework. While an instrumental case study can

be useful without the need to justify its typicality or representativeness (Stake, 1995) this broadly scoped exercise has the richness required both to challenge and test the proposed KDLC while potentially suggesting specific correspondences for future comparison of cases. We now briefly outline some background context for the study.

The research site was a State Government authority (Parks Victoria) responsible for management of a wide range of parks and reserves in Victoria (Australia) (Parks Victoria, 2007a). In 2002, the organisation had identified advantages in embracing the contemporary environmental management paradigm, Adaptive Management (AM) (Stankey, Clark & Bormann 2005) when it commenced a fox-control Adaptive Experimental Management (AEM) program (Robely & Wright, 2003)[1]. The following year this direction was followed when Parks Victoria was directed by government establish an ecological management strategy (EMS) for Box-Ironbark forests and woodlands after an independent inquiry (Parks Victoria, 2007b). In particular, a research and monitoring framework was required for assessing ecological efficacy of different methods of box-ironbark thinning as a basis for the proposed EMS. It has been established that an experimental basis for investigating proposed broad-scale environmental management increases the likelihood of its success (Walters & Holling, 1990; Murray and Marmorek, 2004).

In a given situation AM implements a single cycle not unlike the traditional SDLC or Boehm's spiral model (Boehm, 1988): best practices or experimental candidates are implemented, evaluated and the model is refined. Because field trials can be done in parallel, different candidates can be monitored, learned from and the model adapted for the next cycle. Ongoing reflection and communication (at various checkpoints) help to modify processes and activities. There are also pivotal assessment points at which progress stocktakes and implementation versions are documented. The ongoing and everyday measurements are effectively "normal science" but the feedback aspect adds a more generic and reflective level capable of engendering paradigm change within the organisation and wider community of practice.[2]

It was at this level that the investigator was required to report – to make sure that the recording was happening; that the recordings were being received by those required to think about it, and further, that their observations were being fed back as the AM required. At this level an organisation-wide knowledge development paradigm could be established, suited to the management of future AM (i.e. AEM) projects, necessarily conducted within specific operational sectors.

2. Background research

Knowledge life cycles aim to provide a comprehensive process for the creation, use and evolution of information artefacts along with their associated activities of storage, access, management and disposal. A number of these have emerged from the practitioner literature (e.g. Bergeron, 2003) but tend to focus only on the artefacts themselves, and otherwise lack higher order reflection capabilities. In particular such models generally assume both organisational and practitioner preparedness to implement the requisite processes but lack specified criteria to assess these. Similarly, following a higher order

[1] The term Adaptive Experimental Management (AEM) is often used in the Australian context because the term Adaptive Management can be misused (see discussion by Murray and Marmorek, 2004).
[2] Using the terminology from Kuhn (1970)

review of capability there is no provision for ongoing alignment with strategy or other gap identification. Higher order feedback processes theorised by Argyris and Schön (1978) and by Flood and Romm (1996a, 1996b) provide reflection capabilities suited to assessing knowledge development more comprehensively.

The knowledge development lifecycle (KDLC) presented in Pigott, Hobbs and Gammack (2006) is illustrated in Figure 1, and is now summarised briefly.

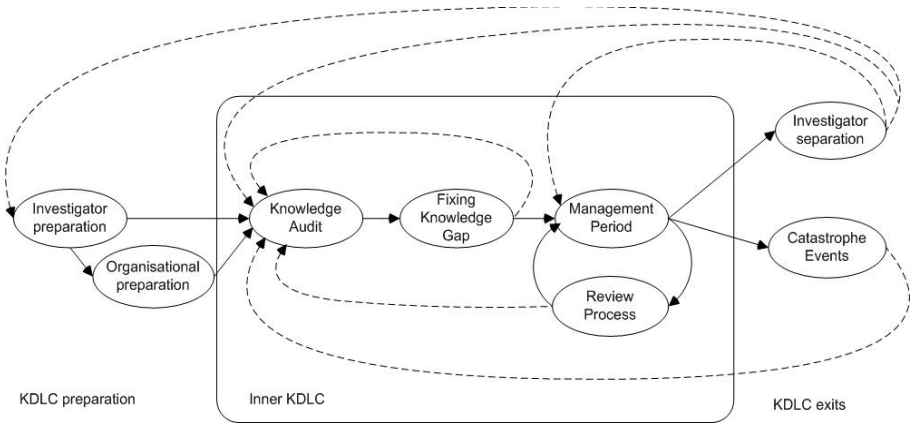

Figure (i) The Knowledge Development Lifecycle (after (Pigott, Hobbs, & Gammack, 2006))

Within the universe of discourse of the organisation which contextualises both investigator and organisation, we identify an 'outer' KDLC, which consists of those relations between investigator and organisation immediately prior to and subsequent to a knowledge audit, and an 'inner' KDLC consisting of those tasks that occur as part of the knowledge cycle within an organisation. This inner cycle includes activities of the formal knowledge audit and gap fixing, and ongoing review and management of knowledge processes as part of normal organisational functioning.

For a knowledge audit to be a worthwhile undertaking for an organisation we suggested it needs to be mature (having a legal, distinguishable structure), viable (with sufficient resources to continue to exist and survive putting a KM solution in place), have a clear decision making process and be self aware. We call this *organisational preparedness*.

The ability to conduct knowledge audits also depends on the maturity and competence of the practitioner. A self-assessment of the investigator is required: an examination of his or her preparedness to conduct a knowledge audit for the organisation, including his or her assumptions, qualifications, expertise, ontological structures, prior work, background knowledge, opinions and prejudices. Explicitly recognising and reflecting on the investigator's state as knowing system ensures integration with that of the organisation as the knowledge audit proceeds. We call this *investigator preparedness*.

In the KDLC the investigator him or herself is recognised as a knowledge entity interacting with the organisation, both of which go through cycles of maturity. Feedback loops within the inner KDLC enable continual monitoring of identification and fixing of

knowledge gaps (in the knowledge audit phase), and ongoing management and review in the maintenance phase.

The final stage of the KDLC is where the knowledge development lifecycle is transcended. There may be a natural end whereby the investigator leaves the organisation under a managed exit strategy and handover process that ensures continuing functioning of the organisation post-review. The KDLC may also end unnaturally through some catastrophe event (such as takeover, merger, and so on) in the wider environment, requiring return to a new knowledge audit.

In Pigott, Hobbs and Gammack (2006) we proposed a checklist for the preparedness of the organisation (as a learning organisation), and the investigator (as a learning professional). These criteria are used as indicators of potential problematic areas for an investigation, and the absence of any of the requirements may suggest tasks that need to be carried out in the KDLC. This checklist is shown in Table (i) with generalised items and criteria that would apply to each.

Requirement	**Organisation**	**Investigator**
Metadata policy	Published, standardised and adhered to	Explicit, standardised and adhered to
Systematic approach to document creation	Mandated situations for creating documents and mandated procedures for how to go about it	Regularised self- and client-centred document creation processes
Common term set (vocabulary or ontology)	Published set adhered to, preferably in conformance with industry standard	Established terminology practice, combined with ability to incorporate terms local to client system
Understanding of organisational needs	Organisational aim (or aims) unambiguous and clearly stated	Distinction between investigator as individual and investigating role in KDLC project
Clear statement of needs at the operational level	Telos for organisation expressed in practical terms as (e.g.) a mission statement	Explicit methodology including (this) KDLC
Systematic naming process for documents	Naming and locating of documents carried out systematically in accordance with a rule set	Naming and locating of documents carried out systematically in accordance with a rule set, with a set of referents to internal processes and external systems under investigation
Chain of custody for documents	Responsibility for document clearly established at all times	Strict versioning and security
Clear process for decision-making	Chain of command and ultimate responsibility	Explicit authorial or editorial responsibility
Awareness of structure of organisation	Unambiguous logical schema for organisation	Individual or team based expert identity
Documentation of processes (minutes, memos etc)	Organisational procedures published and adhered to	Regimen of journaling work and research strictly adhered to

Table (i) KDLC checklist items for organisation and investigator

Parks Victoria[3] was aiming to establish an organisation-wide knowledge development paradigm for managing future AEM projects but knew of no appropriate methodology, although some small-scale standards and directions were emerging from normal practice. In this context it was suggested to the first author (by D.J. Pigott) that the above checklist, together with a suitable combination of existing KM tools might be considered as a basis to assess achievement. Without overarching methodological guidance our approach was based around the tools in current operational use and on the emerging information standards and future strategies developing within the organisation.

3. Research methodology

Our context motivates a case study research strategy. Organisational research rarely lends itself to experimental manipulation, but qualified participant observation is often an appropriate method. Case study research is particularly suited to addressing contemporary events in their real life context, and this grounding ensures a close fit between the data being gathered and the theoretical categories at issue. Whilst the original theory was developed from practical experience with several cases, it had not yet been empirically validated in a formal manner. In establishing content validity we require to relate the theorised components of the lifecycle to practical behaviours and criterion activities in a realistic context. This entails identifying both a suitable research site and an investigator positioned to engage deeply over some time with the critical processes involved.

Because case study sampling is theoretically motivated rather than random, the proposed categories of the KDLC can be populated directly and usefully (Eisenhardt, 1989), allowing for theory testing and extension. The generalisation of findings is to the theory, rather than to other organisations, and the theory here is applied to a single, critical case and coupled investigator. A single case study is indicated when the case meets all the conditions for testing the theoretical propositions (Yin, 1984), and the reflection built into the approach allows for any limitations of the theory or its scope of utility to be identified, along with the requirements for contextualising alternative candidates.

Our research site was ideal for this purpose. Parks Victoria (PV) is a statutory authority with responsibilities to manage Victoria's parks reserves, waterways land and other public land (about 17% of the state) (Parks Victoria, 2007a: Ch. 1). The organisation had grown into an internationally recognised park management agency with significant marine and terrestrial conservation assets, also managing important recreation and heritage sites. Unlike its predecessors, its primary mission is focussed on management of this estate without responsibilities for Statewide policy and private landholder issues. It no longer has a traditional role of scientific observation and investigation; with internal responsibility for development of conservation programs and providing leadership for State Government initiatives. Parks Victoria does however manage a modest external research program through a series of partnerships under its Research Partners Panel (RPP) agreements (Parks Victoria, 2007a: Ch.3). Many of the larger projects can be described as being in the AEM style, where the 'learning by doing' model is ideally suited to an organisation with considerable land management responsibilities, but allowing for research outcomes with RPP organisations as well.

[3] i.e. the Research Branch (Parks & Marine Division) of Parks Victoria

Parks Victoria was at a point where a thoroughgoing assessment of its knowledge management was required across the organisation, to ensure continuing alignment of its purpose and strategy.
In particular, the changing structures and roles had effected unavoidable disruption to the organisation, and whilst it had performed competently on its traditional footing, it was timely to assess the appropriateness of its processes to the new situation. As the exigencies of staffing levels and financial considerations meant that highly human-intensive work was impracticable, the first author considered a knowledge audit would be of value to the Box-Ironbark Thinning AEM.
In the immediate context of this audit, the knowledge concerned the design of the experimental program and the communication process connected with its establishment and implementation in a forested area of regional Victoria.

Case study methodology ideally requires the investigator to have various specific qualities, and Yin (1984) suggests these should include: a firm grasp of the issues being studied, the ability to ask good questions, flexibility and the adaptability to relate observations and data collected to theory responsively and without bias. The investigator had relevant background experience in various areas, including scientific observation and the standard practices of scientific organisations but had no practical KM skills beyond those expected of contemporary professionals in a modern computer-intensive organisation. His knowledge of the operations and processes across all levels of the organisation however positioned him as suited to conduct the audit at the levels specified in the model, rather than in the normal SECI type cycle (Nonaka, 1991) of everyday knowledge production, management and review. Furthermore the participant-observation process of data collection provides "distinctive opportunities" often unavailable to outsiders, for example privileged access to documents and persons, or making insider-informed assessments and telling manipulations within groups or systems that would not be possible otherwise (Yin, 1984, p93).

Given that both organisation and investigator met the preliminary criteria for a knowledge audit, over a 4 month period (from April-July 2007) the investigator followed the structure and processes of the model, to establish three specific outcomes, outlined below.

The first outcome was to articulate comprehensively the organisation's preparedness for ongoing knowledge development and management. This would locate the purpose of the review within an ongoing, specified process, and have the benefit of allowing reporting of the requirements analysis to be unambiguously structured for future audits. The checklist and generic map tools associated with this process identify relevant "what" and "where" knowledge.

The second outcome was to ascertain the organisation's current position in the KDLC. In particular it asked whether it was already iterating within the inner KDLC effectively, or whether the prior existing structures were sufficiently disrupted to warrant reconsideration appropriate to a more radical realignment. Many organisations will have their own specific project guidelines and information standards and thus the checklist is specified at a level of generality to accommodate these.

Thirdly, an organisationally articulated understanding of the separation/changeover event was required. At the end of the process the first author effectively moved from his extended role as a investigator back to normal duties (project management), with the documentation becoming a common property. Part of the design was to have a working consultative system for the organisation, capable of producing graphs and reports on demand to allow an ongoing organisation wide capability in knowledge reviewing and gap identification. This was achieved through preparation of a *Protégé* (Musen et al., 1993); (Noy, Grosso, & Musen, 2000) knowledge base (described in the next section), and incorporating feedback obtained during the knowledge auditing process.

The next section details these three phases, specifying the practical use of the checklist in mapping organisational and investigator features, the identification of knowledge gaps arising from the structural disruptions, and the knowledge based system designed to allow ongoing management and review during periods of stability. Data analysis was guided by the propositions implicit in the checklist, and necessarily the data itself was bound to its organisational context. Techniques used therefore tried to verify the specific propositions using triangulation among documents, email and verbal discussions and interview material, and the researcher's own ("dispassionate") observations.

Because of the non-linear nature of the research, the data collection was driven more by convenience, timeframe and opportunity, than by the ordered list of working hypotheses, but the completion of the analytic strategy was given by the checklist itself. As only a preliminary set of propositions was available, the project resourcing was consistent with the study's exploratory and descriptive nature, and thus thematic codings and frequency counts were not formally used here. For similar reasons, alternative theoretical propositions were not specifically considered, but rather our concern was with the sufficiency of the checklist to the data required for the project's reporting objectives.

4. Results, analysis and discussion

The context of the KDLC investigation was documentation of the proposed research framework for box-ironbark thinning and its future applicability as a management approach. The project[4] comprises planning, operational and scientific activities including:

- Setting up an expert technical advisory committee (The Scientific Reference Group [5] - SRG) to assist with development and review;
- Design of a scientific investigation to evaluate thinning methodology, impacts and feasibility;
- Implementation of a field trial to assess ecological thinning methods[6];
- Development of a scientific monitoring program including research partnerships;
- Completion of scheduled monitoring and reporting of results and assessment of significance.

[4] Detailed in the draft technical manual (Pigott et al. 2006)
[5] The SRG comprised four independent ecologists and a community representative: all highly regarded individuals (Pigott et al. 2006)
[6] The treatment implementation phase of the project may be regarded as from November 2003 to September 2007, including logistics planning, piloting of ecological thinning and completion of thinning and timber removal treatments (Parks Victoria, 2007b)

Here we focus on the trial project's implementation phase using the KDLC steps to find gaps in project design and associated organisational processes and behaviours. We are particularly concerned with the knowledge around the experimental program design and the communication process connected with its establishment and implementation.

At pivotal points workshops and meetings between the investigator and operational staff helped to identify the specific issues checklisted earlier in Table (i). Three essential "articulation"[7] components that support the implementation of AEM complement the formal documentation, namely email texts, phone conversations and informal face-to-face meetings. Whilst the KDLC supports the notion that important communication is documented and archived, this is rarely the case among mobile workers not used to practicing scientific record keeping.

Table (ii) populates the checklist given earlier with data from the case organisation.

Requirement	**Adaptation to AEM project development**
Metadata policy	GIS policy for metadata and GIS standards use ANZLIC Australian Spatial Data Infrastructure (ANZLIC, 2007) PV has recommended data standards to RPP project leaders
Systematic approach to document creation	Clear organisational direction & procedure PV policy "PRO 000B Documenting Processes/Procedures" PV procedure "PRO-041 - Records Management Procedures"
Common term set (vocabulary or ontology)	List of acronyms provided at Induction via Intranet (i.e. Infoweb) Ecological terms defined in documents described in text BUT no explicit glossary equivalent to a metadata statement or dictionary
Understanding of organisational needs	Very clear understanding by research & operations managers evident Understanding of operational needs by senior officers in region Aims / objectives clearly stated (both generic and project level)
Clear statement of needs at the operational level	Documentation of project development & experimental design (corporate file) Implementation notes for field staff (but reliance on a oral "hand-over " process for new staff) Documentation of procedure and methodology for treatment implementation, monitoring and data collection in draft 'Field Guide" (J.P. Pigott et al. 2006)
Systematic naming process for documents	Policy for naming and storing documents in place Naming convention for documents only by staff with some IS background Reliant on individuals being systematic with filing & archiving documents, and managing email (corporate files & IS network)
Chain of custody for documents	Limited custody role by research ecologist for implementation documents No official chain of custody with operations – reliant on staff motivation

[7] Strauss (1985, p2) notes that since "[the relations between actors and tasks] are not automatically articulated, actors must do that too…" and calls the work of doing this 'articulation work'- "a supra-type of work [that] involves also the accountability actions".

Clear process for decision-making	Very clear process for decision making in research design and monitoring Very clear decision making at operations level (based on sample only) Some uninformed/ incorrect operations decisions made on ground (based on sample only)
Awareness of structure of organisation	Good awareness of structure of organisation by research and operations staff (based on sample) Investigator with considerable experience in this and other Government agencies Role of Parks & Marine Division not clear to all field staff
Documentation of processes (minutes, memos etc)	PV have policies as described above Expectation of minutes for SRG meetings backed by preparation and filing of minutes and follow-up progress documents (corporate files) Memos supporting milestone decisions or financial modifications/ OH&S issues made Broad processes of establishing the project in Pigott et al. 2006, Parks Victoria 2007a

Table (ii) The checklist populated with specific data from the research site

The first item on the checklist is *metadata policy* which, in a mature organisation, should be "Published, standardised and adhered to". Parks Victoria policy adheres to Australian standards, in particular ANZLIC (Australian Spatial Data Infrastructure) for Geographical IS. These have been recommended to all research partners. PV appears to have few other policies on metadata and this is an identified knowledge gap. It does not mandate standards for RPPs but presumes they follow their own, and this is a potential source of ontological confusion.

PV has clear direction and specific policy for *creation and archiving of documents* for all projects. This step relies on administrators/ project officers to generate files for new projects and routinely add these to the correct file. Important communication also needs to be documented and filed.

Term sets are commonly accepted as standard in work disciplines associated with information technology and systems. Definitions/ explanations are provided in a draft methodology for the project although they are not usually provided for environmental management projects. A list of acronyms used by Parks Victoria is available for new staff via the Induction page on the agency Intranet.

Aims/objectives for *organisational needs* are clearly stated at induction with a reminder through the annual workplan process development process (and available via the Intranet). In the context of this AEM, aims and objectives have also been clearly stated; however these may not have been communicated to new staff after commencement. This can be identified as an area of weakness as there was a steady turnover of staff during the implementation phase of the project, partially because of the fixed-term nature of the project.

Operational (and technical) needs are well documented for the project through draft methodology (known internally as the *Field Guide* (Pigott et al. 2006)) and detailed in a

poster presented at two conferences (e.g. Pigott, Wright, & Keatley, 2004) and a community day held at one of the parks used in the project. It can be identified that improved information or briefing for new field staff may have improved effectiveness and efficiency (and certainly morale at some stages of the four years). This is also related to staff gaining a technical understanding of the project as well as understanding organisational needs.

With regards to *file-naming conventions*, guidance is given but there is no overall specification. There are limited guidelines for naming and filing email communications. Staff are encouraged to be consistent regarding this within their own work, to make project management easier (e.g. Investigator's own email and shared corporate network storage files). The investigator has previously, in his role as research ecologist (which includes project management and liaison tasks), filed necessary documents and archived important email texts in a systematic manner. In his experience this is common practice for people involved in research (and project management) but less common amongst field staff involved in operational work (and away from their office most of the time).

Chain of custody exists for holders of official files (registered as borrowers in the file management database TRIM). Responsibility is placed on individuals and managers to return these file when staff leave their section or Parks Victoria. However there appears no mechanism or audit in TRIM to follow-up files that have not been returned in a certain period of time. This potential problem is exacerbated by an increasing number of fixed-term staff and staff moving regularly to different roles.

There is very good *decision-making* in the organisation, essential for emergency management responsibilities. The process for this lies with the organisation's chain-of-command made simpler by having relatively few positions situated between the chief executive and park rangers & field service officers. Clear guidelines for some aspects of operational work (e.g. fire management) are provided and supported by a high level of training. This supports effective administration of a large AEM with many operational tasks required at different sites (if correct information is provided and distributed).

Most staff have a good understanding of the *organisation's structure* at induction and particularly through training and awareness for emergency management. However the investigator has been able to observe that an understanding of the role of Parks & Marine Division activities (including research and project development) by field staff is not as good as it could be. This area is already receiving some attention with training available in 2007 for some staff (e.g. pest plant and animal monitoring protocols).

Policies already mentioned state an expectation for correctly *documenting procedures*. For this AEM project it has been clear that Minutes for SRG and other important meetings be made. This is backed by preparation and filing of these minutes and follow-up progress documents. Other processes such as requests for additional funding or assessment of working conditions (OH&S reviews) are well documented with templates to assist preparation and procedures to be followed.

An important related issue is the quality of information provided in all formal and informal types of communication and documentation. There are a number of reasons for this and results of investigating strengths and weaknesses of the project are influenced by this. Factors include the use of a communication plan, level of interest and responsibility

of the project and procedures for inspecting and recording completion of specified site works.

In addition to the checklist, a part of the knowledge auditing process, use was also made of a knowledge based management system, Protégé (Noy, Grosso, & Musen, 2000). Protégé was developed at Stanford University as a mechanism for storing semistructured data which had strong network features, to record epidemiological and clinical information from medical trials.

Protégé enabled the occurrences of data points in various domains of knowledge (people, documents, processes, outcomes) to be stored in a single data repository, and emergent network phenomena to be observed. Development of sociograms which effectively illustrated the many relationships between activities (e.g. research) and resources (e.g. people) demonstrated there was potential for examination of knowledge protocols for the project, and identification of gaps in communication or processes that were absent.

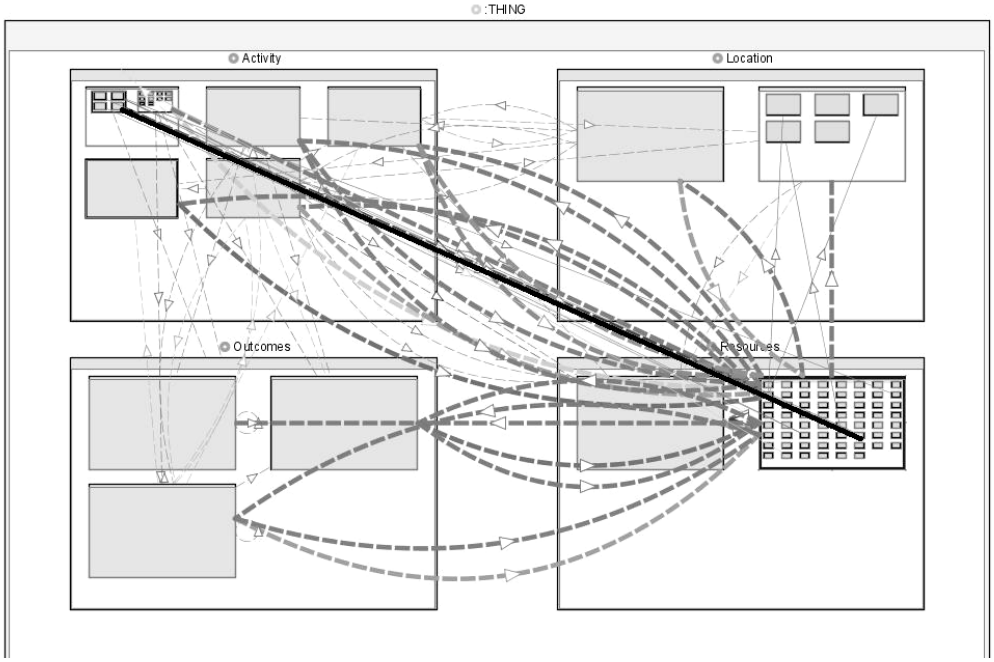

Figure (ii) – A snapshot of the Protégé Knowledge Repository showing some identified information flows

Figure (ii) shows the Protégé knowledge repository with links showing for example, an information flow between a (field) activity and an (organisational unit's) database. The dark line here represents a link between vertebrate fauna monitoring and a research partner's project-level database.

Queries were run to find contradictions in the data structure, and Protégé's visual tools permitted a large variety of diagrams to be produced that allowed immediate feedback on the structure. Protégé has a late binding schema, enabling the investigator to have an adaptive structural representation of the things being recorded: thus the knowledge base always reflected the latest thinking. The interface tools enabled snapshots of continuously updating dynamic knowledge configurations with time-stamped detail at all levels for drill down and analysis.

With regards to the organisation's position in the KDLC, results were mixed. In particular the ability to reflect on information flows relating to large research projects suggested that whilst aspects of the inner loop were working effectively, at the outer level the processes were ineffectively aligned.

Finally, the last part of the outer KDLC concerns the investigator joining and leaving the KDLC. In this instance these were role-based rather than contractual or temporal, as the internal secondment completed with the scheduled return to normal duties. The work of the Box-Ironbark Thinning Trial continued, but was enhanced through learning about the inherent KM responsibilities required, which then fed back into the organisational practice as the model requires.

5. Conclusions

The KDLC model presented in Pigott, Hobbs and Gammack (2006) had emerged from practical experience in multiple cases but had not been more widely validated. The present study provided a unique opportunity to test theory comprehensively against an exemplary case where both the organisation and the investigator were suited to the work.

Any case study involving participant observation may be criticised on grounds of potential bias. This criticism is considered to apply here only minimally, for the following reasons. Firstly, the investigator is a trained and professional scientist, conscious of observational bias and issues around inappropriate theory fitting. Secondly, the organisation mandated an impartial audit, freeing the investigator from the pressure to advocate on political rather than objective considerations. Thirdly, the other potential problems (identified by Yin (1984)) hardly apply here: namely lack of time for *observation* due to *participation* commitments, and migrating from a "researcher" to a "supporter" of the organisation. Finally, the design of the model requires reflection and articulation at all levels so that the ongoing processes following separation depend minimally on the presence and tacit interpretations of a particular individual.

While the theory here was tested critically against a single organisation, a larger design replicating the approach across several organisations would help to support or extend the theory. This single case was considered in some depth, and in addressing the theoretical assertions in the model provides a paradigm for similar studies, though it was not originally designed to serve as a pilot for a wider, multiple case design. While it is *a priori* plausible that organisations of similar size and complexity will have similar issues in knowledge management, there may be specific sectoral or cultural differences that challenge the theory's universality, and the research design would also have to control for any variability of the investigator. Whilst the checklists are explicit, the KDLC is specified at a high level of abstraction and more experience with it in practice will help detail some of its components in more operational terms, though there is always a trade-off between a theory's level of specification and its explanatory range (see Western, 2001).

The immediate implications from this work apply both to theory and to practice. A practicable approach to a major KM activity has been applied in a realistic setting and found competent to its subject. It has passed its first serious test, but naturally more

systematic investigation is required to identify extensions, contradictions, refinements and other apparatus entailed in building a robust theory. Whilst other, perhaps proprietary, knowledge lifecycles may also be effective in KM audit contexts, these appear rarely to have been theoretically evaluated; nor do they make provision for ongoing internal governance and investigator reflection.

In relation to wider theory in information systems macro-structural issues such as power, implicit in the design but not highlighted here, suggests an important direction for related work. Carlsson (2003) considers the limitations in several current forms of "post-research", that is, a range of post-positivist research strategies now commonly practiced in information systems. Drawing upon Layder (1993) he picks up on certain weaknesses in grounded theory including its neglect of historical macro-structural phenomena that give institutional backdrop to the focal micro-phenomena around situated interaction that characterise much grounded theory research. Power issues were not in evidence in this particular case study, though the general political situation around resourcing in any organisation naturally limits what is achievable.

This study demonstrates a wedding between theory and practice in that the KDLC and checklist components emerged from numerous practical KM exercises in which the gaps emerged, requirements became evident, sensitising categories and themes were identified and applied, and eventually converged to a stable model by close comparisons between the presenting situation and the observational and reporting categories. This general process is similar to the ideal of grounded theory (Glaser & Strauss, 1967) though not designed under that rubric. Having produced a testable theory however, systematic investigation can follow – "hypotheses" suggested, a theory driven sample chosen and the utility of the theory further assessed. This focus on empirical activity and utility reflects a pragmatic ethos, but one which can nonetheless be theorised and abstracted for a wider community. After more experience with the KDLC's application, further practical recommendations for its implementation may also become detailed.

In addition the quality of information gathered and documented could in future be ascertained by reference to organisationally applicable criteria and standards. In this case Parks Victoria is developing a KM strategy which proposes higher standards for the areas of concern (Parks Victoria, 2007c). Information quality is integral here and the semantic quality of information models in terms of their accuracy, completeness, consistency and so on is important. In this regard the work of Poels et al (2005), which aims towards the formal evaluation of semantic quality for information models, appears promising.

In summary, our study has shown the KDLC's applicability in a substantial practical setting, and demonstrated that the theoretical categories can be usefully applied without obvious distortion although further work on the information quality and methodological aspects would be useful extensions. Future studies might also fruitfully include a multiple case design with a single investigator, which, while controlling to some extent for investigator preparedness would allow for comparisons, contradictions and challenges to emerge.

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