PRACTICAL APPLICATION OF A KNOWLEDGE DEVELOPMENT LIFE CYCLE: ADAPTIVE EXPERIMENTAL MANAGEMENT IN BOX-IRONBARK FORESTS OF VICTORIA

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CATEGORY: Research paper

ABSTRACT

We describe the practical application of a reflective knowledge development lifecycle (KDLC) designed to be used by organisations reviewing their KM processes and capability. The KDLC had emerged from practical experience but had not been more widely validated. The present study provided a unique opportunity to test theory comprehensively against an exemplary case where both organisation and investigator were suited to the work. A case study research strategy was used. Applying the theory in a practical setting, an environmental scientist used the model and associated knowledge representation and visualisation tools to find gaps in processes and design in the implementation of an organisation-wide research framework. Developing the knowledge repository highlighted inherent complexity among people, resources, research activities, operational tasks and communication outcomes. The study helped validate the KDLC's utility in ensuring alignment of organisational processes and strategy; demonstrating its useful application in a practical setting. A replication across several organisations would help refine the model beyond this critical test in a single organisation, while suggesting further practical recommendations. The results of the study suggest that the KDLC is of value to practitioners in providing a checklist approach for knowledge auditing; to theorists developing organisational KM models and those using test-case strategies. The outcomes will particularly interest information and environmental professionals involved in establishing adaptive management projects.

ABSTRACT (using headings):

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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. The KDLC had emerged from practical experience but had not been more widely validated. The present study provided a unique opportunity to test theory comprehensively against an exemplary case where both organisation and investigator were suited to the work.

Design/methodology/approach
A case study research strategy was used. Applying the theory in a practical setting, an environmental scientist used the model and associated knowledge representation and visualisation tools to find gaps in processes and design in the implementation of an organisation-wide research framework.

Findings
Developing the knowledge repository highlighted inherent complexity among people, resources, research activities, operational tasks and communication outcomes. The study helped validate the KDLC's utility in ensuring alignment of organisational processes and strategy; demonstrating its useful application in a practical setting.

Research limitations/implications (if applicable)
A replication across several organisations would help refine the model beyond this critical test in a single organisation, while suggesting further practical recommendations.

Practical implications (if applicable)
[covered in previous and next section]

Originality/value
The results of the study suggest that the KDLC is of value to practitioners in providing a checklist approach for knowledge auditing; to theorists developing organisational KM models and those using test-case strategies. The outcomes will particularly interest information and environmental professionals involved in establishing adaptive management projects.

KEYWORDS
Knowledge development life cycle; case study; adaptive experimental management; organisational change and review; Box-Ironbark ecological thinning; Protégé

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1. Introduction

In previous work (Pigott, Hobbs & Gammack 2006) we introduced a knowledge development life cycle 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 a case study research strategy in a suitable environment.

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 case, (which we describe in more detail presently) involved finding the gaps in organisational processes and project design for the documentation and implementation of an organisation-wide 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 an Australian State authority (Parks Victoria) responsible for management of a wide range of parks and reserves (Parks Victoria, 2007). In 2002, the organisation had identified advantages in embracing a new environmental management paradigm, Adaptive Experimental Management (AEM) (Johnson 1999; Walters & Holling 1990) when it commenced a wide-spread fox management program (Robely & Wright 2003). The following year this direction was followed when directed by government establish an ecological management strategy for Box-Ironbark forests and woodlands following an independent inquiry (Pigott et al. 2008). In particular, a research

and monitoring framework was required for assessing ecological sustainability of different methods of box-ironbark thinning as a basis for this strategy. In a given situation AEM 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.[1]

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 AEM required. At this level an organisation-wide knowledge development paradigm could be established, suited to the management of future 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 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 (Flood & 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.

[1] Using the terminology from Kuhn (1970)

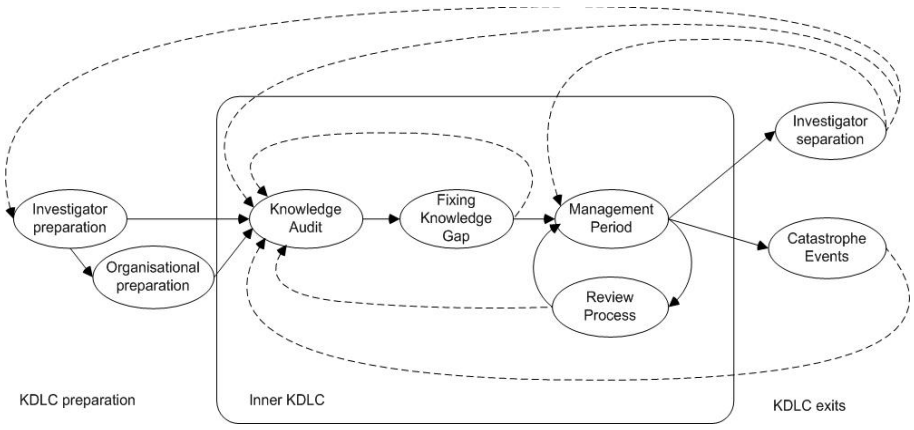

Figure (i) The Knowledge Development Lifecycle (after (Pigott, Hobbs & Gammack 2006)

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. The specific approach and criteria used in any given situation needs to be adapted to the organisation, and is described later for the case organisation here.

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 journalling work and research strictly adhered to

Table (i) KDLC checklist items for organisation and investigator

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, Parks Victoria, was ideal for this purpose. Parks Victoria 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 2007). 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. However Parks Victoria does have a responsibility for development of conservation programs and providing leadership for State Government initiatives. It also has a role in monitoring and scientific investigation for parks and reserves, particularly ecosystems such as Box-Ironbark forests and woodlands (Parks Victoria 2007). As part of its support for this function, Parks Victoria manages a modest external research program through a series of partnerships under its Research Partners Panel (RPP) agreements. 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.

Within the AEM framework for the Box-Ironbark thinning trial, Parks Victoria was continually assessing the projects' progress to ensure its completion against Phase I objectives (Pigott 2009). As part of this process, it was apparent that documenting the knowledge management attributes of the project could be valuable in linking operational needs and scientific monitoring (Pigott et al. 2007). 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 commenced a knowledge audit. 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 3 month period (from April-June 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.

Thirdly, an organisationally articulated understanding of the separation/changeover event was required. At the end of the process the investigator effectively moved from his extended role as a consultant back to regular duties, 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.

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[2] comprises planning, operational and scientific activities including:

- Setting up an expert technical advisory committee (The Scientific Reference Group [3] - 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[4];
- Development of a scientific monitoring program including research partnerships;
- Completion of scheduled monitoring and reporting of results and assessment of significance.

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 meetings between the investigator and operational staff helped to identify the specific issues checklisted earlier in Table (i). Three essential "articulation"[5] 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) Parks Victoria (PV) have recommended data standards to RPP project leaders
Systematic approach to document creation	Clear organisational direction 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 Ecological terms defined in documents described in text BUT no explicit glossary equivalent to a metadata statement or dictionary

[2] As described in the updated progress report for the project (Pigott 2009)
[3] The SRG comprised four independent ecologists and a community representative: all highly regarded individuals (Pigott et al. 2008).
[4] The treatment implementation phase of the project (Phase I) 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 (Pigott 2009).
[5] 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".

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 experimental design Implementation notes for field staff Documentation of procedure and methodology for treatment implementation, monitoring and data collection in 'Field Guide" (Pigott et al. 2008)
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 and managing email
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
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
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 Memos supporting milestone decisions or financial modifications/ OH&S issues made. Broad processes of establishing the project in (Pigott et al. 2008)

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. 2008) and detailed in a poster presented at two conferences (Pigott, Wright & Keatley 2004) information presented to the community at two of the parks used in the project and a number of conference presentations (e.g. Palmer et al. 2009). 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. Instead it is up to staff to be consistent for their own projects to make it easier to use files (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 in the file management database TRIM). There is an audit procedure for checking whether staff names issued with official files correctly match TRIM records, which may be part of a broader "WorkCentre Business Review". However, responsibility is placed on individuals and managers to return these files to Records Management when staff leave their section or Parks Victoria. 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 easier by reduced bureaucracy; with relatively few positions situated between the chief executive and park rangers & field service officers. 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 Division

(formerly Parks & Marine) activities (including research and project development) by field staff is not as good as it could be.[6] 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. The strengths and weaknesses of the project are influenced by the quality of the information provided as well as its presence or absence. Factors affecting quality of communication and documentation are likely to 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) 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 observations of fungus and a research partner's database.

[6] Also supported by the senior authors "treatment audit" reported in Pigott (2009).

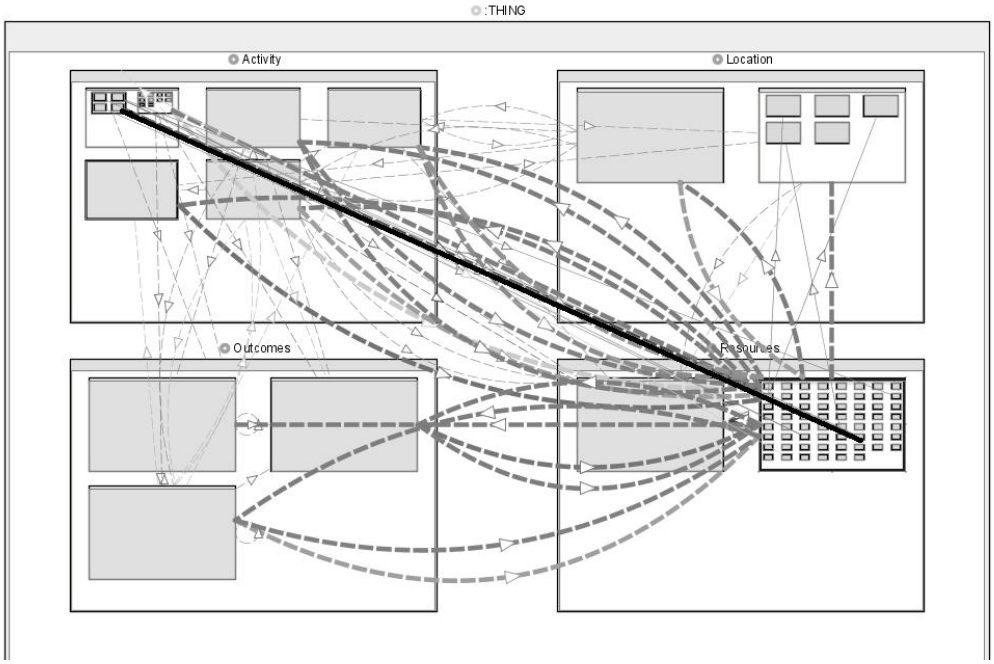

Figure (ii) – A snapshot of the Protégé Knowledge Repository showing some identified information flows

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.

Developing the Protégé repository highlighted the research framework's inherent complexity among people, resources, research activities, operational tasks and communication outcomes. 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, with some bottlenecks of unanalysed data, or the absence of institutional feedback.

Finally, the last part of the outer KDLC concerns the investigator joining and leaving the KDLC. In this instance these events 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. The Protégé KB continues to be developed and updated as a long term repository of knowledge about the project.

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 tradeoff 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 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. Future studies might 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.

Acknowledgements
The first author acknowledges the financial support of Parks Victoria for his involvement in the Box-Ironbark Ecological Thinning Trial. The authors wish to thank Tony Varcoe (Parks Victoria) for comments on the final manuscript as well as two anonymous reviewers of an earlier version.

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