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A principled approach to knowledge elicitation and transfer in organisations

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Abstract

This thesis describes research carried out to investigate and address the problems related to the elicitation of knowledge from experts and its transfer to potential stakeholders in organisations. Essentially, knowledge elicitation and transfer is understood as a process of enabling people to acquire new capabilities while others who already have such capabilities explicate the domain specific knowledge underlying their performance. Knowledge elicitation and transfer have become essential processes in an environment influenced by the rate and direction of technological change, and characterised by an increasing complexity of tasks and greater employee mobility.

The starting point of this research was the implementation of a knowledge elicitation and transfer strategy based on the use of social software at Cranfield University. Failure of that software to achieve its aims raised awareness of the limitations of purely technology-based approaches to knowledge elicitation and transfer. A collaboration with a gas turbine manufacturer then provided the setting for the trial of a people-based approach to knowledge elicitation and transfer.

In a literature review an endeavour was made to study and provide an overview of the main contexts in which the knowledge elicitation and transfer problems have arisen. For each of the areas identified, an overview of the advantages and limitations of the techniques that have been used was provided. The literature shows that despite its importance for organisations, there is no method which is guaranteed to achieve knowledge elicitation and transfer. This motivated the researcher to formalise, refine and validate the newly developed approach by applying it in different organisations.

The research has resulted in a number of contributions to knowledge and benefits for the organisations involved. A key contribution is a development of a new method called Concepts-Modelling-Experience (CoMEx), based on collaborative modelling of domain-specific knowledge. The applications of CoMEx in the field suggest that it overcomes some of the main deficiencies of well known approaches to knowledge elicitation and knowledge transfer, and that it brings additional benefits to organisations. However, the research has identified areas where there is significant scope for further research and investigation.

A Isbet, Isabella y Alex.

A la memoria de mis padres.

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List of Abbreviations

KM	Knowledge management
KE	Knowledge elicitation
KT	Knowledge transfer
KET	Knowledge elicitation and transfer
CoMEx	Concepts-Modelling-Experience
GTM Ltd	A Gas Turbine manufacturing company where a knowledge elicitation and transfer project was run between 2007 and 2008.
PowerTech UK Ltd	A Power Conversion Systems manufacturing company where a series of knowledge elicitation and transfer projects were run between 2008 and 2009.
MoDInfra	A section within the Ministry of Defence where a knowledge elicitation and transfer project was run in 2009.
RQ	Research question
TC	Theoretical construct

Chapter I

INTRODUCTION

Knowledge elicitation from experts and its transfer to the less experienced is not a new topic. However, these processes have gained relevance in recent years as information and communication technologies have developed and experts' mobility has increased. Despite their importance for organisations, there is no method which is guaranteed to achieve the elicitation of knowledge from experts and its transfer to potential stakeholders.

This research has been undertaken to understand the problems associated with the elicitation and transfer of knowledge and develop a new strategy for addressing those problems. As a starting point of the thesis that reports such work, this chapter provides an introduction to the context of the research, the problems associated with the elicitation and transfer of knowledge and the solution proposed.

1.1. An introduction to the path followed by this research

This thesis reports research in the field of knowledge management. The research reported focuses on the topic of knowledge elicitation from experts and its transfer to individuals and workgroups, as well as the issues affecting these processes at organisational level.

Success of most knowledge elicitation and transfer methods has been limited by a number of issues that include the following:

- Issues determined by the characteristics of the knowledge sought to be elicited and transferred, such as its quality, ease of learning and applicability.
- The demands of the knowledge elicitation and transfer processes in terms of time, skills and other resources.

- Problems related to the selection of experts and their ability to contribute their knowledge.
- Motivational issues related to the elicitation of the knowledge from experts and its acquisition and application by individuals and workgroups.

This research has been undertaken to understand the problems associated with the elicitation and transfer of knowledge and then develop a new strategy for addressing those problems. The work has involved an exploration of a range of approaches to knowledge elicitation and knowledge transfer, also considering the emergence of technologies such as social software and their adoption by areas such as knowledge management.

Upon trial of different methods in the field, the research defined a new, people-based approach to knowledge elicitation and transfer which becomes the focus of the work reported. The new approach is based on face-to-face, facilitated, collaborative modelling of domain specific knowledge involving experts and potential stakeholders. Some of the key aspects of the new approach have been validated through its application in four different organisations. However, the research has identified areas where there is significant scope for further research and investigation.

This chapter describes the background and motivation that constitute the foundations of the research reported in this thesis. It then moves on to describe and formalise the research problem. Finally, the chapter provides a summary outline of the proposed approach to address the problem of knowledge elicitation and transfer in organisations, which will be analysed in detail in later chapters.

1.2. Research context: knowledge elicitation and transfer in organisations

1.2.1. The concept of knowledge elicitation and transfer

According to Hickey and Davis (2004), *elicitation* is related to learning, uncovering, extracting, surfacing and discovering. Cooke (1999) describes knowledge elicitation (KE) as the process of explicating domain specific knowledge underlying human performance. Knowledge transfer (KT) is a concept related to capability acquisition,

according to authors such as Argote and Ingram (2000) and Mowery et al. (1996). Knowledge elicitation and transfer (KET) will therefore be understood by this research as

The process of enabling people to acquire new capabilities while others who already have such capabilities explicate the domain specific knowledge underlying their performance.

1.2.2. Historical development

References to the processes of eliciting knowledge from experts and transferring it to apprentices can be traced back to ancient texts (Davis and Steinglass, 1997; Kristeller, 1978). However, it is since the 1950s that their research and practice gradually acquired a new dimension, influenced by the emergence of new information and communication technologies.

Buckner and Shah (1990) argue that in a conference held in 1956 a group of experts discussed formally, for the first time, the need for means for automating the capture, storage, processing, and application of human knowledge. They suggested that “*every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it*”. With this, the so-called knowledge engineering field originated, focusing on the modelling of human knowledge in a machine-usable form.

One of the first areas that benefitted from the principles of knowledge engineering was the development of expert systems. However, the implementation of expert systems experienced a major drawback when it was found that it seemed to take longer for computer scientists to elicit knowledge from experts than writing the expert system software (Shadbolt and Milton 1999, p. 310; Hoffman and Lintern 2006, p. 204). This problem, known as the “knowledge acquisition bottleneck”, raised awareness among researchers and practitioners about the challenges associated to the elicitation and transfer of knowledge.

In addition to expert systems development, a significant number of other areas have been concerned with the elicitation of knowledge from experts and its transfer for reuse

by other individuals and workgroups. These include information systems requirements analysis, training and development, and knowledge management. These fields have approached the elicitation and transfer of knowledge from a variety of perspectives, defined to a large extent by the role that technology has played in each approach.

1.2.3. Technology-based vs. people-based approaches to KET

Prior to the 1980s KET processes were still heavily reliant on traditional mechanisms. These included techniques such as storytelling and mentoring, applied during handover or induction processes in organisations.

As computer-mediated methods for acquiring knowledge emerged, argues Gruber (1989, p. 293), the elicitation and encoding of knowledge from people became the focus of research and practice in many organisations.

The philosophical notion of tacit knowledge developed by Polanyi (1966) posed a challenge for computer-mediated approaches to KET. Despite the relative success of storing coded knowledge in computers, Polanyi's views implied that human-to-human knowledge transfer would remain necessary (Hoffman et al., 2008). Soon the limitations of KET and the issue of 'traditional' knowledge elicitation as opposed to 'automatic' knowledge acquisition became the focus of attention for authors such as Buckner and Shah (1990), Hoffman et al. (1995), Neale (1988), Dhaliwal and Benbasat (1990) and Michalski and Chilausky (1999).

Throughout the last two decades significant problems have continued to arise when organisations undertake KET strategies fully based on the use of software or approaches that are purely based on people-based mechanisms. However, organisations continue to try to elicit knowledge from experts and transfer such knowledge to its potential stakeholders using approaches that rely on extreme positions. These range from asking an expert who is leaving to record everything they know to the use of software to gather raw data and generate a knowledge repository (Hoffman et al., 2008, p. 86). Thus, defining and implementing the right approach to knowledge elicitation and transfer continues to be one of the main challenges of integrating KM in organisations today (McInerney, 2002).

1.3. Research problem: limitations of knowledge elicitation and transfer strategies

1.3.1. The definition of the research problem

A significant milestone that marks the beginning of the definition of the research problem was the implementation of a KM project at Cranfield University in 2006. The author of this research played a key role in such a project by identifying and facilitating the sharing of a set of valuable knowledge resources across the research community.

Many of the individuals involved in that project felt that social software would be an ideal mechanism to support the sharing of their knowledge. After exploring different techniques, a Wiki was developed and deployed in the hope that people would spontaneously use it to share their knowledge. The Wiki was initially very successful. A significant number of researchers contributed to its contents and almost all made use of it. However the usage declined over time and attempts to stimulate interest by providing incentives for contributions were unsuccessful.

The researcher found that success of the Wiki was ephemeral, and one year after its launch use was minimal. However, the outcomes of the project at Cranfield University helped the researcher understand the shortcomings of purely technology-based approaches to knowledge elicitation and transfer.

An opportunity then arose to intervene in a KET project within a Gas Turbine Manufacturer in 2007. The aim of the project was twofold:

- Knowledge about fault diagnosis in gas turbines was to be elicited from Help Desk experts and transferred to a number of engineers across different departments.
- A system was to be produced with the aim of helping the organisation to study whether automatic fault diagnosis in gas turbines could reduce the workload of Help Desk experts.

The two aims were addressed in a combined manner. Facilitated by the researcher, Help Desk experts and engineers from the design, development and manufacturing

departments were involved in the collaborative development of a model of fault diagnosis in gas turbines, discussing their symptoms, root causes and probabilities. That model took the form of a Bayesian network which was later used by the researcher to build a fault diagnosis system.

By the end of the collaboration it was concluded that the project had delivered both the expected knowledge elicitation and transfer and a system for automatic fault diagnosis. Furthermore, a number of additional, unexpected outcomes were identified. These included the recordings of many hours of discussion of key engineering issues, the emergence of new communities of professional interest within the organisation, a Bayesian network for the training of customers and personnel working in the field, and a rise in management's awareness of the need to share the knowledge of experts on a regular basis.

The collaboration with the Gas Turbine Manufacturer marked the beginning of the development of a new approach to KET, which was reported in its early versions by Garcia-Perez and Ayres (2009). The new approach later became the main contribution of this research to the body of knowledge about KET available in the KM field. The new approach followed four main stages, namely:

1. The identification of key concepts within the knowledge domain.
2. Using those concepts as the starting point of the development of models of the knowledge domain by the KET team.
3. Analysing the alignment between those models and the experience of participants.
4. Reviewing the process with participants on an individual basis.

1.3.2. The research questions

The primary research question

During and after the collaboration with the Gas Turbine Manufacturer, a review of theories on KET was conducted. Such a combination of theory and practice within the KET area resulted in the definition of the overall guiding question for this research as:

How can the limitations of existing approaches to knowledge elicitation and transfer in organisations be overcome?

The researcher was aware of the complexities intrinsic to the problem defined by the primary research question. Overcoming the limitations of existing approaches to knowledge elicitation and transfer would require research of a number of areas that included:

- What the existing approaches to KET are.
- How their success is evaluated.
- What their limitations and also their advantages are.

This understanding motivated the definition of a number of additional, more specific research questions derived from the main research question, which also needed to be answered, at least partially, during the research.

Additional research questions

The knowledge elicitation and transfer project at the Gas Turbine Manufacturer was based on a face-to-face interaction between experts and stakeholders. However, the strategy used to facilitate the dynamics of the KET team developed informally as the project progressed. The researcher acknowledged that there was significant room for improvement in that area and therefore the following research question was defined:

RQ-1. How can knowledge elicitation and transfer processes benefit from the lessons learned in other areas involving facilitated group collaboration techniques?

The collaborations with Cranfield University described earlier and with the Gas Turbine Manufacturer focused on the concepts of *knowledge sharing* and *learning*. The results of the subsequent review of the literature made the terms '*knowledge elicitation*' and '*knowledge transfer*' relevant for this research. Then the following research question was defined:

RQ-2. What do the concepts of knowledge elicitation and knowledge transfer mean and to what extent are they related to other concepts such as learning?

The success of the collaboration with the Gas Turbine Manufacturer was to a large extent derived from combining the elicitation and transfer of knowledge about fault diagnosis in gas turbines with the development of a Bayesian network. This fact raised

a number of questions about the applicability of the same principle in other areas. Such issues were summarised in the following research question:

RQ-3. How can models and the modelling process support the knowledge elicitation and transfer processes?

After discussions with the project sponsor at the Gas Turbine Manufacturer it became evident that only the organisation was able to identify the experts in areas related to gas turbine operation, and the stakeholders of their knowledge. This, in addition to the complexities of the issues associated with identifying who is an expert and determining what makes a person an expert, motivated the outline of the following research question:

RQ-4. How can the experts and practitioners who will be involved in knowledge elicitation and transfer processes be identified?

The experience of successfully eliciting knowledge about a product (i.e. gas turbines) and the process of diagnosing their faults suggested that the same approach could be applied in other domains or even to elicit other types of knowledge. As a result the following research question was outlined:

RQ-5. What types of knowledge can be effectively elicited from experts and transferred to other individuals and groups within the organisation?

There was enough information to believe that a people-based approach to knowledge elicitation and transfer could achieve better results than a technique that was purely based in the use of technologies. However, the potential role of information and communication technologies in a knowledge elicitation and transfer project was still not clear and therefore the following research question was defined:

RQ-6. What is the role of technologies in knowledge elicitation and transfer processes?

The collaboration with the Gas Turbine Manufacturer concluded with a presentation delivered by the researcher with the aim of communicating the success of the project to senior management. On an individual basis, all participants related the success of the project to the sharing of experts' knowledge. However, during the final presentation the primary outcome of the project was seen by management as the delivery of the Bayesian

network and the fault diagnosis system. This raised the researcher's awareness of the difficulties inherent to measuring and communicating success of a KET project. As a consequence the following research question was defined:

RQ-7. How can success of knowledge elicitation and transfer processes be assessed?

Addressing these additional research questions within the body of this dissertation will contribute to raising the understanding of the main research problem and constitute in itself the momentum driving this research. Therefore, the author will seek to address all of them in this dissertation. It does not mean, however, that definitive answers will be provided for each of these additional questions. Some questions will only be given a partial answer or a framework for further reflection.

1.4. Research aims and objectives

On the basis of the research problem identified as a result of the collaboration with the Gas Turbine Manufacturer during early stages of this research, the aim of this research was defined as:

The definition and validation of a new approach to KET that overcomes some of the main limitations of existing KET techniques.

In order to achieve such an aim, the following objectives were established:

1. Define what this research will consider to be 'knowledge elicitation' and 'knowledge transfer'. Study the main contexts in which these areas have arisen and the limitations they have encountered.
2. Review key areas that emerged from the early stages of this research as potentially informative for the development of a new approach to KET.

In particular, such a review will focus on the facilitation of group dynamics and the attempts to use models and the modelling process to support knowledge elicitation and knowledge transfer.

3. Study the methodological choices available for the study of processes such as knowledge elicitation from experts and its acquisition by stakeholders.

Select an appropriate research strategy, design and methods, and justify their feasibility and competence for the conduct of this research.

4. Define a new approach to KET in organisations, which addresses the key limitations encountered by other techniques.
5. Define a structured method that organisations can use to implement the proposed approach to KET.
6. Apply the new KET method in organisations with the aim of collecting data for the assessment of its validity.
7. Draw and verify conclusions on the validity of the new approach to KET on the basis of data collected in organisations.

1.5. Research contribution

The collaboration with the Gas Turbine Manufacturer sought to deliver benefits for both parties involved, namely the researcher and the organisation itself. Thus, an attempt to share knowledge about fault diagnosis in gas turbines across departments was combined with a process of developing a model that could facilitate the implementation of an automatic fault diagnosis system.

As a result of such combination the basis of a new approach to KET were outlined. Its main characteristics include:

- It is fundamentally a people-based approach which uses but does not depend on information and communication technologies to achieve its aims.
- Experts in the knowledge domain and potential stakeholders collaborate in the same location and at the same time to achieve a common goal which is not necessarily presented to them as the elicitation and transfer of knowledge.
- Knowledge elicitation and transfer is based on the collaborative development of models of the knowledge domain.
- A facilitator who is not necessarily an expert in the knowledge domain plays a key role in the KET processes.

The newly outlined approach to KET was refined and validated during the two years that followed the collaboration with the Gas Turbine Manufacturer. As KET can only be understood in the context where those processes take place, those refinement and validation processes were based on a series of collaborations with other knowledge-intensive organisations. The aim of all of these projects was the elicitation of relevant expertise from those individuals regarded as experts by their organisations, and the transfer of such expertise to other individuals and workgroups.

In its dealing with people, organisations, business and management, this research has been shaped from its early stages by the context within which it has been carried out. Additionally, it has focused on the study of concepts such as knowledge, knowledge elicitation and knowledge transfer which can only be measured through the interpretive understanding of the meaning of such concepts for organisational participants. Thus, a qualitative research strategy based on a multiple case study defined the methodology employed by the researcher to draw the conclusions of this research.

1.6. Thesis structure and summary of primary contributions

This thesis is structured in three parts, as shown in figure 1.1. The first part comprises the review of the literature and research methodology. The proposed approach to knowledge elicitation and transfer is presented in part two. Part three focuses on the assessment of this new approach to KET. The thesis concludes with a discussion of the path followed by the research and the areas for further work.

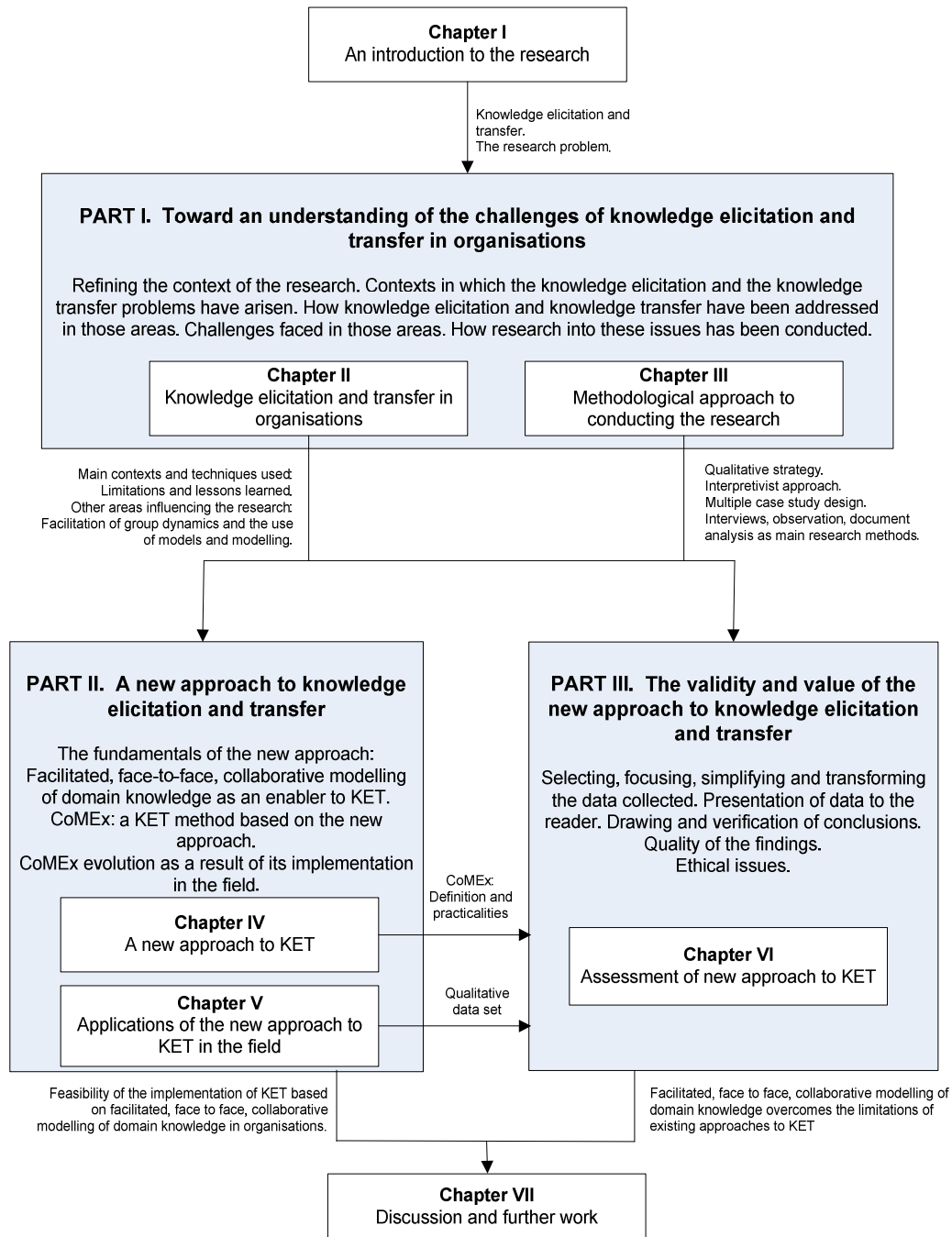


Figure 1.1. Outline of the thesis structure

The topic of knowledge elicitation and transfer and the outline of the research problem have been discussed in this chapter. In an attempt to set the context of the research, chapter II analyses techniques for knowledge elicitation and knowledge transfer that have been applied within different domains, their limitations and lessons that can be

learned from their study. Additionally, chapter II includes a review of key topics within the main areas that have influenced the KET approach proposed by this research.

Before moving into the specifics of this study, details of the methodology that has been used to address the research problem are included in chapter III.

At the start of part two the new approach to KET proposed by this research is presented. The origins and fundamentals of the new approach are followed in chapter IV by the definition of a method for KET. The method, named CoMEx, was designed by following the principles of the new approach proposed. In order to facilitate the implementation of a KET exercise using CoMEx, the description of the last KET project conducted as part of this research is also included in chapter IV.

The different applications of the new approach in the field enabled the collection of data that was relevant for its assessment. However, the field work also led to the evolution of CoMEx as a KET method. Such an evolution was a result of a continuous process of refinement based on the lessons learned during its implementation in different organisations as part of a multiple case study. Both the data collection and the refinement of the method are described in detail in chapter V.

The third part of the thesis focuses on the analysis of the data collected during the field work. Such a large volume of data resulted mostly from observation, document analysis and interviewing participants during the multiple case study. Chapter VI describes how this data set was reduced to make it manageable and enable its understanding. The results of the data reduction and analysis are presented using tables that help understanding how conclusions were drawn. The quality of the findings of the research and ethical issues associated with its conduct are also discussed as part of chapter VI.

Finally, the key contributions of the research are summarised in chapter VII which also sets out the areas that will benefit from further study.

Chapter II

A REVIEW OF THE LITERATURE ON KNOWLEDGE ELICITATION AND TRANSFER

In this chapter a review of the key areas of related research is presented. The review has been conducted and presented with two considerations in mind. Firstly it is intended to provide the reader with a view of the main contexts in which the problems of knowledge elicitation and knowledge transfer have arisen. The aim has been to present the main aspects that have to be considered by a fresh attempt to overcome the limitations that these areas have encountered. This is particularly important for the definition and assessment of a new approach to knowledge elicitation and transfer. Secondly, a review is conducted into the key areas that emerged from the early stages of this research as potentially informative for the development of a new approach to knowledge elicitation and transfer. In particular, the analysis focuses on the facilitation of group dynamics and the attempts to use models and the modelling process to support the processes of knowledge elicitation and knowledge transfer.

2.1. The focus of the literature review

The limitations of existing approaches to KET in organisations define, as discussed in chapter I, section 1.2, the main research problem driving the research reported in this dissertation. Section 1.2 also discussed some of the sub-problems that relate to the main research problem, represented by additional research questions.

There are therefore many domains where research has been conducted which provide background on the problem of KET in organisations. The literature review reported in this chapter aims to:

8. Establish and clarify the key domains where the KET problem has arisen and the limitations of existing approaches within these domains.

These domains are categorised according to whether they have been concerned with the elicitation or the transfer of knowledge. Techniques within each of these categories are analysed in detail.

9. Explore areas and techniques which inform the development of a new approach to knowledge elicitation and transfer in organisations that overcomes such limitations.

These areas include facilitation of group meetings and the use of models and modelling in the elicitation and transfer of knowledge. Techniques which are relevant for this research are analysed.

10. Investigate how success of KET has been measured in those domains where related problems have arisen.

The analysis of key domains where the KET problem has arisen included the discussion of mechanisms of evaluation of the techniques used. This informed the mechanism implemented by this research in order to evaluate success of the KET technique proposed.

To achieve such aims this literature review concentrates on the analysis of a number of research topics that include:

- Knowledge elicitation, knowledge transfer and their relation with the concept of learning.
- Facilitated group collaboration techniques.
- The use of models and the modelling process as part of knowledge elicitation and knowledge transfer processes.
- Specific issues related to the knowledge elicitation and transfer process in organisations, including:
 - The knowledge that may become the focus of the process.
 - The selection of participants in the process.
 - The role of technologies in the process.

- Evaluation methods for KET techniques.

In order to address these issues this chapter will start by outlining in section 2.2 the main contexts where the KET problem has arisen. Because of the relevance of this problem in the field of knowledge management, section 2.3 describes KET developments in this area. This is followed by an analysis of key issues related to knowledge elicitation and knowledge acquisition in sections 2.4 and 2.5 respectively. Section 2.6 reviews developments in two domains that have informed the approach to KET proposed by this research. These are the facilitation of group meetings and the attempts to use models and modelling to support the processes of knowledge elicitation and knowledge transfer. Finally, section 2.7 provides a summary of the key issues that inform the findings of this research.

2.2. Main contexts where the knowledge elicitation and transfer problem has arisen

From the origins of knowledge engineering in the 1980s knowledge elicitation and knowledge transfer have been the focus of a growing number of areas (Kendal and Creen, 2006). The reasons for such a rise not only in the number but also the nature of contexts where the KET problem has arisen include:

- Developments in information and communication technologies, which created a new medium for information storage and its sharing, and
- An increase in the need for knowledge elicitation from experts and its transfer to other organisational participants due to an increase in experts' mobility e.g. by moving to another part of the company, starting up their own businesses, taking on positions with other organisations, as well as retiring (Hofer-Alfeis, 2008).

Following on from the definitions outlined in chapter I, section 1.3, Levine and Gilbert's (1999) argue that the stages of knowledge elicitation and transfer can often be summarised as: idea creation, idea sharing by those who hold the knowledge and idea adoption by others, facilitated by organisational structures and practices. If the generation of ideas is excluded from the analysis by assuming that the relevant knowledge is already available, Levine and Gilbert's (1999) view defines two key topics

to look at when analysing the KET problem. These are elicitation of knowledge from individuals and its acquisition by others.

Knowledge management refers to the processes related to managing (i.e. identifying and leveraging) the knowledge of the organisation to help it compete by increasing its innovativeness and responsiveness (Alavi and Leidner, 2001). Elicitation of knowledge from those acknowledged as experts and its acquisition by other individuals and workgroups are key to the leveraging of the knowledge of the organisation.

There are, however, other areas that have given rise to knowledge elicitation and knowledge acquisition problems over the last 20 years. Based on the review carried out of the literature on this topic and the analysis and appreciation of the domain of knowledge elicitation and transfer, such areas appear to fall into the following categories:

1. Areas that have focused explicitly on eliciting knowledge from individuals on the assumption that they had a significant understanding of specific issues within a domain. Some of these are:
 - Expert systems development: Expert systems have been defined as computer programs that aimed at solving real-world problems that would normally require the intervention of a human expert (Lehner and Adelman, 2009). The development of such systems normally requires the elicitation of knowledge from an expert in the domain.
 - Information systems requirements engineering: a process by which ‘what is to be done’ by software developers to meet the needs of their users is understood (Leite, 1987). Knowledge in the form of requirements is therefore elicited from individuals.
2. Areas that have addressed or sought to support the acquisition of knowledge by individuals so that they could apply that knowledge in the workplace. These have included:
 - Training and development programmes: Programmes that aim to develop the organisation’s knowledge capital by enhancing the knowledge of its individual employees and, ultimately, their performance (Curado, 2006).

- Action learning: A development strategy based on the principle that individuals learn with and from each other by working on real problems and reflecting on their own experiences (Prescott et al., 2009).
- Social software: The term refers to “*the use of computing tools to support, extend, or derive added value from social activity*” (Avram, 2006, p.1). Such software has been developed to serve as a medium to address, among other issues, the sharing and acquisition of knowledge by individuals.

The remainder of this chapter will outline some of the main issues related to the processes of knowledge elicitation and knowledge acquisition based on the analysis of the areas mentioned above. The analysis follows the same order in which the areas have been presented and starts in the following section with a review of KET developments in the KM field.

2.3. Knowledge elicitation and transfer in the field of knowledge management

2.3.1. Introduction

Despite the range of definitions of knowledge management (KM) available, KM is described by different authors as an active process involving the creation of knowledge, the intentional elicitation of knowledge, and the ability to share knowledge across the organisation (McInerney, 2002, p. 1015). Thus, applying techniques to elicit knowledge from experts and facilitating knowledge acquisition become critical parts of KM processes (Liebowitz, 2001, p.11).

Given the relevance of the knowledge elicitation and knowledge transfer problems in the field of KM, the focus of this research, this section will briefly outline the main developments of KET within the KM field. Particular emphasis is placed on the nature of the techniques being used, their limitations and the issue of evaluation of their success.

2.3.2. KET in KM: a summary historical evolution

By the late 1980s, when KM had not yet been defined as a field, knowledge elicitation and knowledge acquisition in organisations had been the focus of different research and practice areas. Knowledge engineering, a field to be analysed later in this chapter, had already developed techniques for knowledge elicitation from experts, whilst Gaines (1989, p. 251) had presented the knowledge acquisition activity as “*playing an essential and continuous role in skilled performance, rather than as a separate and separable activity*”.

According to Prusak (2001) the beginning of KM as a research and practice area can be traced back to the early 1990s. Soon the IT-oriented, application-heavy approaches, which emphasise the acquisition and storage of organisational knowledge, became the most prevalent form of implementing KM initiatives (Hellström et al., 2001).

By the mid 1990s the philosophical notion of tacit knowledge that had been developed by Polanyi (1966) became the basis of Nonaka and Takeuchi's (1995) theory of the knowledge-creating company. Their view raised awareness of the importance of the knowledge elicitation and transfer processes in organisations and influenced heavily the way such processes were approached. Tacit knowledge then became a challenge for both knowledge management in general and knowledge acquisition in particular, implying that human-to-human knowledge transfer would remain necessary despite the developments in technology-based KM systems (Hoffman et al., 2008).

By the late 1990s authors such as Shadbolt and Milton (1999, p. 310) had concluded that knowledge elicitation and transfer, like many other issues and problems in the KM field, were familiar territory to those that had been involved in knowledge engineering. In particular, they argued that many of the principles, methods and tools of knowledge engineering were relevant for the field of KM.

Although organisations continue to easily “*fall into the technology trap and devote all resources to technology development, without planning for KM implementation*” (Rus and Lindvall, 2002, p. 34), the so-called problem of the leaving expert has recently gained significant relevance for organisations due to an increase in experts' mobility (Hofer-Alfeis, 2008). This has raised awareness of the importance for organisations of

implementing knowledge retention strategies that focus on eliciting the knowledge of experts and transferring to other organisational participants (Young, 2006).

Today Hoffman et al. (2008) understand that knowledge elicitation and transfer remains as one of top four challenges of KM, while Lawton (2001) suggests that KM processes such as knowledge elicitation and transfer still require a greater focus on methodology and not on technology.

2.3.3. KET techniques applied as part of KM initiatives

In an attempt to define what the author understands as a KET technique this section revisits the concept of KET that was defined in chapter I, section 1.2.1 of this thesis, as

“the process of enabling people to acquire new capabilities while others who already have such capabilities explicate the domain specific knowledge underlying their performance”

The Oxford English dictionary defines *technique* as “*a way of carrying out a particular task*” and also “*a procedure that is effective in achieving an aim*”.

A KET technique will therefore be understood by this research as

“a procedure that is effective in enabling people to acquire new capabilities while others who already have such capabilities explicate domain specific knowledge”.

A range of KET techniques have been applied in organisations as part of wider KM initiatives. These range from the use of software that claims to capture knowledge and make it available to others, to tape recording experts and then labelling the videotape and putting it on a shelf where knowledge is, in the view of Hoffman et al. (2008, p. 86), neither usable nor useful.

Examples of specific KET techniques that are widely used within the KM field include:

1. Technology-based techniques that consist of using particular software that claims to capture or store knowledge and make it available to organisational participants (Hoffman et al., 2008, p.86).
2. People-based techniques such as:

- Knowledge capture interviews: Interviewing experts, recording the interviews and making it available to organisational participants. Young (2006) reports an example of knowledge retention interviews where lessons, advice and recommendations are drawn from the interview and made available to practitioners as a 'knowledge asset' (p. 31).
- Mentoring: Often seen as a relationship in which a senior practitioner works to support the career of a more junior individual, typically an apprentice (Alavi and Leidner, 1999; Anderson and Shannon, 1988). Becerra-Fernandez et al. (2004) argue that mentoring opportunities are affected by issues such as the increasing complexity of tasks, greater employee mobility, etc.

Other initiatives such as communities of practice may also result in the elicitation of knowledge from experts and its acquisition by practitioners. However, these have not been designed specifically for the purposes of knowledge elicitation and transfer. They therefore do not fit the definition of KET technique outlined above and will not be covered by this analysis.

2.3.4. Limitations of KET techniques in use in the KM field

Based on the review of the literature on this topic, the main limitations of the KET techniques used in the KM field can be structured in the following categories:

1. Issues related to the characteristics of the knowledge being elicited

After the analysis of the concepts of organisation, knowledge and acquisition, Gaines (2004) concluded that the *perceived validity* of the knowledge being elicited can affect individuals' perception of the value and applicability of such knowledge and those of the KET process.

Gaines' view can also be found in research carried out in the field of psychology, focusing on issues related to the characteristics of knowledge during the process of its acquisition by individuals (Hoffman and Lintern, 2006, p. 43). Such research raises specific questions such as who is an expert, which affect the perceived validity of their knowledge, and discusses the potential difficulties in identifying experts in the workplace (Salas and Rosen, 2009, p. 104).

For those techniques that rely on the use of technology-based KM systems for the elicitation and transfer of knowledge the following limitations have been identified:

- Issues related to the *retrievability* of knowledge stored in a KM system (Rech et al., 2006).
- The inappropriate *quality* of the knowledge (Ras et al., 2005).
- *Learning*-related issues: The actual impact that the technique and the system being used could have on the acquisition and application of knowledge by individuals. Ras et al. (2005) argue that the learning requirements are not always considered or explicitly addressed by the KM system.

Such issues, particularly those related to knowledge stored in ICT-based systems, are not exclusive to the field of KM. The review of the literature reported in the remainder of this chapter suggests that they arise in most areas concerned with KET.

2. Requirements of the KET process

Not only does knowledge elicitation from experts take time, skills and resources, as pointed out by Young (2006, p. 33). Consulting and acquiring such knowledge in order to put it into practice, particularly when it is embedded in KM systems, is also a time and effort consuming activity (Stenmark, 2001).

With regard to technology-based KET techniques, Ras et al. (2005) see the main limitations in:

- Identifying new knowledge to be added to the KM system, as this is a process that relies on individuals and teams deciding to report such new knowledge.
- Structuring any new knowledge to make it available through the KM system. While structure enables retrieval of the knowledge, it also lowers its value. Additionally, structuring the knowledge is a time consuming and complex task.
- The individual communication skills of the knowledge contributor, as this may have a negative impact in the value of the contributions.

3. Motivation

King et al. (2002) referred to “*how to motivate individuals to contribute their knowledge to a KM system*” as one of the ten most important issues to resolve in the field of KM.

There are a number of reasons for that lack of enthusiasm to share their knowledge, including the following:

- Experts may feel that they are supplying others with knowledge without receiving any profit for such contribution (Rech et al., 2006).
- Experts may perceive the sharing of their knowledge as dangerous if they feel that their competitors could use the shared knowledge (Ras et al., 2005, p. 399).

For the particular case of technology-based KET techniques, Ras et al. (2005, p. 399) argued that users of a KM system often refuse to apply the knowledge it contains due to a variety of reasons that include:

- Lack of confidence in its validity (determined by issues such as its currency), and its quality (e.g. determined by factors such as not including enough information about negative issues or failures).
- The risks involved in applying the knowledge of others.
- Problems in understanding the documented knowledge. These were also discussed by Rech et al. (2006).
- The “*not invented here*” syndrome. This is mentioned by Rus and Lindvall (2002) as another significant cause of reluctance in reusing knowledge available in KM systems because of its different origins.

2.3.5. Evaluating success of KET strategies in KM initiatives

Patton (2001) argues that despite the relevance of the acquisition of knowledge by individuals and workgroups for the success of KM strategies, evaluation of KM initiatives often focuses on the immediate usability of the results of the strategies. In contrast, the conceptual use of the results of KM initiatives, which helps organisations in the medium to long term by influencing thinking and deepening understanding, is

often overlooked by evaluation. Given the difficulties that most authors experience when trying to link knowledge elicitation and knowledge acquisition causally to organisational results in the short to medium term (O'Neil and Marsick, 2007, p. 126), many organisations fail to address the issue of evaluation of the actual KET that takes place as a result of their KM initiatives.

2.3.6. Summary

The processes of knowledge elicitation and knowledge transfer have been part of KM since the field originated in the early 1990s. The different approaches to implementing KM in organisations have resulted in the application of a range of KET techniques where technologies have played a significant role. However, there is awareness of the importance of implementing people-based strategies, which has been stimulated by issues such as the increase in employees' mobility.

Despite the number of techniques being applied in organisations, KET processes still face limitations which are mainly related to:

- The characteristics of the knowledge that is to be elicited from experts and transferred to other organisational participants.

Particularly relevant have been the quality and perceived validity of the knowledge, its retrievability from knowledge-based systems and the ways in which its representation supports the actual application of the knowledge by people.

- Requirements of the KET process. The time, skills, resources needed to identify, communicate, structure, find, retrieve and acquire knowledge.
- Individuals' motivation to share their knowledge and also to understand and apply the knowledge of others.

Given the difficulties that most authors experience when trying to link knowledge elicitation and knowledge acquisition causally to organisational results, evaluation of success of KET processes is not always carried out. In cases, evaluation focuses on the impact of the overall KM initiative in the business of the organisation instead of the

success of KET processes and its long-term, strategic effect in the understanding of the organisation and its competencies.

These issues constitute part of the context of this research and will therefore be addressed during the design, implementation and validation of a new approach to KET in organisations.

2.4. Areas that have addressed the elicitation of knowledge from individuals

Eliciting knowledge from individuals on the assumption that they have a significant understanding of specific issues within a domain has been a matter of concern in different areas even before the KM field originated. The fields of expert systems development and information systems requirements engineering sought to elicit knowledge from individuals with the ultimate aim of producing working systems. However, in doing this experts in both domains had to address issues that remain valid in relation to the elicitation of knowledge.

2.4.1. Expert systems development

Buckner and Shah (1990) defined as expert systems the application-oriented tools that result from the coupling of an intelligent system with a knowledge base containing facts and rules as these would be applied by one or more human experts.

The heart of the expert system development process was defined by Hayes-Roth et al. (1983) as “*the transfer and transformation of problem-solving expertise from a knowledge source to a program*”. Once in operation, Shadbolt and Milton (1999, p. 310) argued, the expert system would allow such expertise to be applied in the field by other individuals.

The knowledge elicitation problem in expert systems development

Knowledge elicitation from experts was a key stage in the development of expert systems. Such a process was based on the role of a knowledge engineer, who acted as an intermediary between experts and computers. Knowledge engineers would not only elicit the knowledge from experts; they would also transform such knowledge into application-oriented tools (Hayes-Roth, 1980; Amble, 1987). The role of knowledge

engineers in terms of eliciting and acquiring the knowledge from experts included, as described by Buckner and Shah (1990, p. 26), the following actions:

- Identification of variables and constraints that the human expert uses as input factors when solving “real world” problems.
- Discerning the step-by-step processes which enable the human expert to transform these factors into decisions.
- Conveying the acquired knowledge in ways which
 - Relay the actual methods employed by the human expert,
 - Are understandable by prospective users, and
 - Will be applicable by the expert system.

Knowledge elicitation techniques used by knowledge engineers

Knowledge engineers engaged with human experts in a variety of ways in order to elicit and acquire their knowledge with the aim of producing such application-oriented tools.

These methods included:

- The think aloud problem solving technique, based in learning from experts by making them say what they are thinking while solving specific problems (Watson, 1920; Hayes, 1986, p.353; Ericsson and Simon, 1993).
- The cognitive task analysis technique, which seeks to describe and represent knowledge underlying decisions and judgements made by experts (Hoffman et al., 1998; Schraagen et al., 2000).
- Different types of interviews, with particular emphasis on structured interviews that sought to elicit an outline of the cognitive task and related information such as variables affecting the choice of solutions and the rules that connect such variables (Shadbolt and Burton, 1995, p. 323) .
- A combination of two or more of the methods mentioned above (Hoffman et al., 1995, p. 140)

Limitations of knowledge elicitation techniques used

From the analysis of the literature on the field of expert systems development, the main limitations of the knowledge elicitation techniques used in this field can be grouped into the following categories:

1. Requirements of the knowledge elicitation process:

Hellström et al. (2001) argue that describing knowledge in a structured way and adding information on the context of the specific experience is an activity that requires significant effort and dedicated skills. The knowledge engineers were typically not people with a deep knowledge of the application domain. However, they had to gather the domain knowledge and then implement it in a form that the machine could use (Shadbolt and Burton, 1995, p. 322).

Knowledge elicitation methods used by knowledge engineers were very time-consuming (Hoffman et al., 1995, p. 141). This gave origin to what was known as the “knowledge acquisition bottleneck”, i.e. it seemed to take longer for knowledge engineers to elicit knowledge from experts than to write the expert system software (Shadbolt and Milton, 1999, p. 310; Hoffman and Lintern, 2006, p. 204).

As Buckner and Shah (1990, p. 18) argued, the knowledge elicitation process “*typically succumbs to human imperfections. Furthermore, experts are often restrained by their motivation, time and location factors when striving to express, apply, and explain their knowledge.*”

2. The knowledge elicitation process often relied on one expert’s view.

Authors such as Neale (1988, p. 135) have argued that the knowledge elicitation methods used by knowledge engineers were not effective. Among other reasons, they argue, those methods placed an “*unjustified faith in textbook knowledge and what experts say they do*”. Additionally, knowledge engineers were not able to reconcile different and sometimes conflicting views of more than one expert. As a consequence, a single expert was often appointed and the knowledge engineer attempted to build the expert system in the image of a unique acknowledged expert (David et al., 1993, p. 10). Thus, Hayes-Roth (1984) argued, the knowledge elicitation process became increasingly limited by the fact that no single person had

the needed expertise to consider the increasing number of possibilities required by more and more problems.

3. Issues related to the characteristics of the knowledge. These included:

- The applicability of knowledge

More than just producing the expert system was needed in order to make the knowledge of experts available to practitioners. As Buckner and Shah (1990, p. 24) pointed out, “*inferencing capabilities of an intelligent system do not, in and of themselves, constitute applicable knowledge*”.

- Learning-related issues

Shadbolt and Milton (1999, p. 310) argued that expert systems had a poor performance in what they called ‘learnability’ in reference to the extent to which the knowledge stored in the system could effectively be learned by individuals so that they could perform a task.

Summary

Given the similarities between expert systems and knowledge-based systems as technology-based tools that contained knowledge and aimed at supporting individuals in the implementation of tasks, elicitation of knowledge in both fields faced a number of common challenges and had relatively similar limitations. Such limitations included the following:

1. The requirements of the knowledge elicitation process.
2. The fact that the knowledge elicitation process relied on one expert and the ability of a knowledge engineer who did not always have enough background knowledge to collaborate in the production of a knowledge base.
3. Issues related to the characteristics of the knowledge.

Additionally, motivational issues affected the experts’ willingness to contribute their knowledge.

It has to be said, however, that the limiting effect of some of these issues over the elicitation of knowledge is greater in the context of expert systems development than in

areas such as knowledge management. This is the case of dealing with conflicting opinions of different experts, which is arguably less problematic for KM. However, all the issues listed above inform the development of a new approach to KET in organisations reported in this dissertation.

In relation to the evaluation of the outcomes of the knowledge elicitation process in the context of expert systems development, the number of cases reported was less significant. The ultimate purpose of this field made researchers and practitioners focus primarily on evaluating success of the expert system as a final product instead of the evaluation of the process of eliciting knowledge from experts, which would be only one of the stages of implementing the expert system.

The research areas that received the greatest attention at the time included working with domain experts and development of techniques for knowledge elicitation (Shadbolt and Milton, 1999, p. 310; Gill, 1995, p. 53). However, the limitations in these areas were among the main drivers of the long-term expert systems disuse.

2.4.2. Information systems requirements engineering

According to Nuseibeh and Easterbrook (2000), the primary measure of success of a software system is the degree to which it meets the purpose for which it was intended. As early as 1981 Boehm (1981) found that many software-related projects failed to meet their purposes because their developers did not conduct an adequate requirements analysis.

The process by which software engineers learn from their customers, users, and other potential stakeholders in order to develop systems that meet their needs has been called information systems requirements engineering (Hickey and Davis, 2003).

The knowledge elicitation problem in the field of requirements engineering

Loucopoulos and Karakostas (1995) found that the fields of knowledge elicitation and information requirements elicitation had so many commonalities that they could learn from each other, and even suggested that the two schools should have merged. Thus, the lessons learned from the field of requirements engineering become a relevant input for the new approach to KET proposed by this research.

Elicitation techniques used by software engineers

There was a significant number of knowledge elicitation techniques used by software engineers in the field of requirements analysis. Nuseibeh and Easterbrook (2000) classify these as follows:

- Traditional data collection techniques used in qualitative research, such as questionnaires, different types of interviews and document analysis (Goguen and Linde, 1993).
- Group elicitation techniques such as brainstorming sessions and focus groups (Goguen and Linde, 1993). These techniques will be covered in section 2.6 of this chapter.
- Prototyping, on the assumption that software designers “*develop only well-understood features in building the evolutionary baseline, while using throwaway prototyping to experiment with the poorly understood features*” Davis (1992).
- Cognitive techniques that consisted in asking a subject to engage in some task and concurrently talk aloud, explaining their thought process. An example of this is the protocol analysis technique, similar to the cognitive task analysis technique already discussed in session 2.4.1.
- Contextual techniques such as participant observation and introspection, which are based on the software designers imagining what kind of system they would want if they were to do the job, and then developing such a system (Goguen and Linde, 1993, p. 2).

Of all the techniques mentioned above, Goguen and Linde (1993) highlight interviews, introspection and protocol analysis as the most commonly used in the field of information systems requirements engineering.

Limitations of knowledge elicitation techniques used

Davis (1982, p. 4) argued that there were three major reasons affecting the elicitation of knowledge describing information systems requirements. These were:

- The variety and complexity of the knowledge to be elicited

- The constraints of humans as information processors and problem solvers
- The complex patterns of interaction among users and analysts in the knowledge elicitation process

In an attempt to be more specific, McDermid (1989) identified ten elicitation problems which were later classified by Christel and Kang (1992) in three main areas as follows:

- Problems of understanding, which can be detailed as follows:
 - Users may have an incomplete understanding of their needs
 - Users may have a poor understanding of computer capabilities and limitations
 - Analysts may have a poor knowledge of problem domain
 - User and analyst may speak different languages
 - Ease of omitting “obvious” information
 - Conflicting views of different users
 - Requirements are often vague and untestable, e.g. the concepts of “user friendly” and “robust”.

Some of these limitations resonate with the problems faced by experts in the fields of KM and expert system development. Hence they acquire particular relevance to the purposes of this research.

- Problems related to the scope of the system, which include:
 - The boundary of the system is often ill-defined
 - Unnecessary design information may be given, which may bias the definition of the system
- Problems of volatility of the requirements given by the fact that these evolve over time.

Although the author acknowledges their validity in the context of information systems design and development, the last two categories of limitations are less significant for the purposes of the research reported in this dissertation. This research is not concerned

with the development of working systems and therefore the evolving nature of knowledge is not seen as a limitation.

Evaluation of requirements elicitation

Evaluation of the strategies to conduct the elicitation of information requirements was carried out only to a limited stage, according to the reviewed literature. Similar to other fields concerned with the development of working systems, evaluation was focused on the system produced instead of the process of its development.

However, authors such as Christel and Kang (1992, p. 39) approached the evaluation of requirements capture methodologies by looking at their:

- Effectiveness, i.e. whether the methodologies achieved the highest valued goals. In practice 'achieving the highest valued goals' was interpreted as whether the elicited requirements were valued by users.
- Efficiency, i.e. the extent to which the goals were achieved without consuming more resources than necessary. In practice efficiency was related to the cost of the requirements elicitation process.

A second approach to evaluation of requirements elicitation methodologies was reported by Flower et al. (1990). These authors propose an evaluation strategy that assesses the value of a specific requirements elicitation method by comparing it with other methods that had the same aim.

In the view of the author of this dissertation, the approach suggested by Christel and Kang (1992, p. 39) has more weight than the latter because it relates success of the knowledge elicitation method to the views of its users.

Summary

It is acknowledged that knowledge elicitation techniques applied to capture information systems requirements have an impact in the extent to which a system meets the needs of its users, which in turn determines its value. The techniques used by software developers overlap with those applied in the fields of KM and expert systems development, and also with techniques traditionally used in research. As a consequence, their limitations have common characteristics.

If focus is not on the issues that affect the system to be developed, it can be argued that software developers had to deal with the following categories of problems:

1. The characteristics of the knowledge to be elicited.
2. Communication: the ability of individuals to communicate their knowledge and of analysts to understand it.

In terms of evaluation of knowledge elicitation techniques in this field, an attempt to combine quantitative measures such as cost of the technique with qualitative factors such as users' perception of value of the elicited knowledge becomes a valuable input for the research reported in this dissertation.

2.5. Areas that have addressed the acquisition of knowledge

The acquisition of specific knowledge by individuals and groups has been the focus of research and practice in different areas. The analysis in this dissertation does not focus on knowledge acquisition as in the field of formal education. Nor does it look at the specifics of how individuals learn. Instead, the analysis in this section concentrates on a number of areas that have sought to help individuals and workgroups to acquire knowledge for it to be applied in the context of the organisation where they operate. The fields that have informed the approach to KET proposed by this research and are therefore covered in this review are training and development programmes, action learning, and the growing use of social software within organisations.

2.5.1. Training and development programs

A continuous programme of training and development for its human resources is essential for a competitive organisation to achieve higher productivity, better on-the-job performance and improved quality (Tennant et al., 2002). According to Laird et al. (2003, p.7), training and development is concerned "*not only with helping individuals to fill their positions adequately but also with helping entire organizations (sic) and subdepartments to grow and develop*". Therefore training and development programmes in organisations may encompass many other areas. In the foreword to Kirkpatrick's (2005) book, Anderson sees competency development, outsourcing, e-

learning and even KM as areas that have emerged in the broader field of training and development.

There are two sets of challenges associated to knowledge transfer in the field of training and development. These are related to the process of the trainee learning from the training provider, and to the transfer of the training into the organisation (Seyler et al., 1998). The relevance of this field for the research reported in this dissertation is determined by the former set of challenges and, in particular, the knowledge transfer strategies used.

Knowledge transfer techniques used in the field of training and development

Swanson and Holton (2009, p. 274-277) describe the training and development processes in two categories according to their focus on individuals or groups. Specific training methods that focus on the acquisition of knowledge by individuals and groups are classified by Laird et al. (2003) according to (1) who determines the content of the training programme, and (2) the level of participation of the trainees. Figure 2.1 provides a two-dimensional list of methods used in the field of training and development:

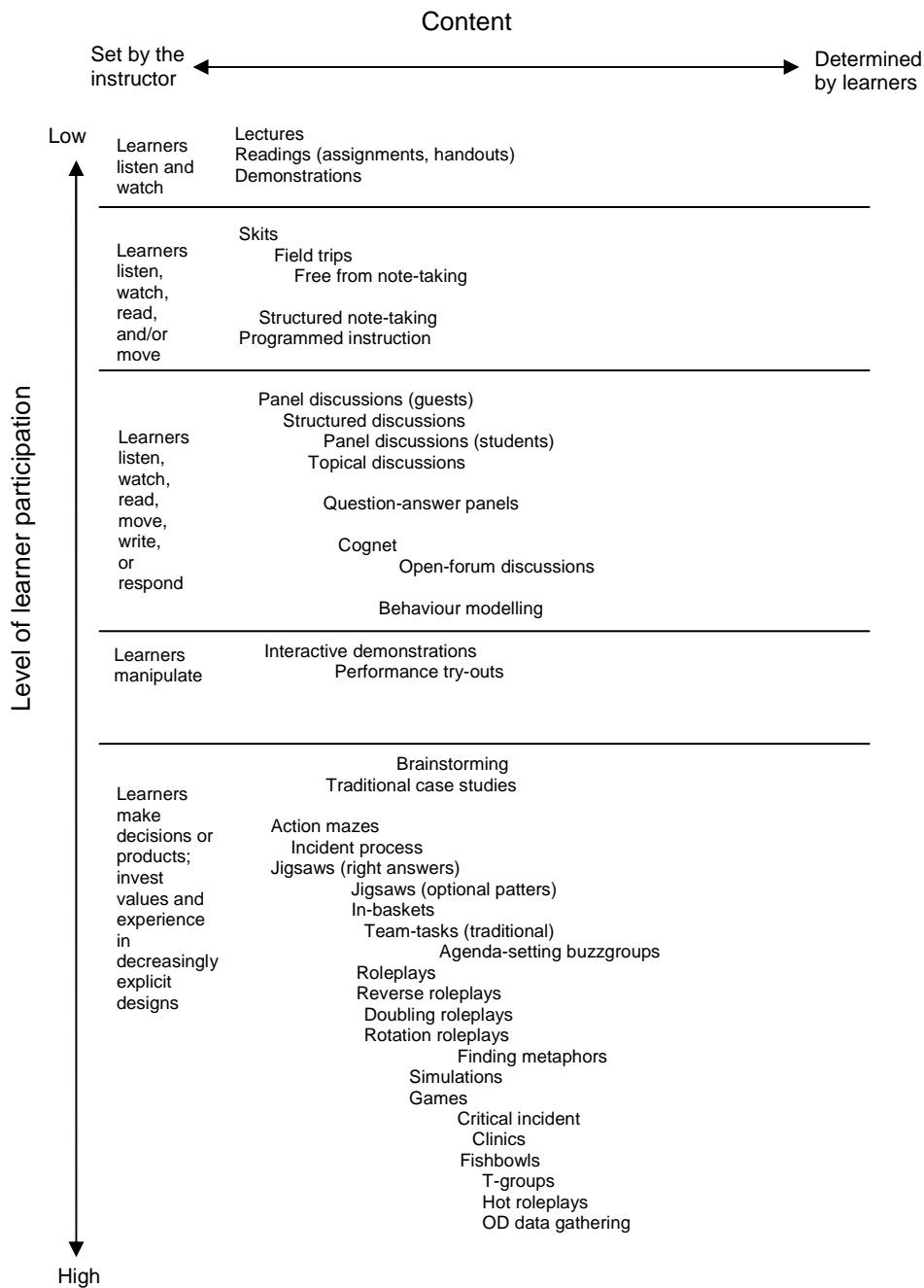


Figure 2.1. Two-dimensional list of training methods – from Laird et al. (2003, p. 153)

An exhaustive review of all the training methods mentioned in the literature is beyond the scope of this analysis. However, this section briefly discusses some of those methods that have informed the approach to KET proposed by the author in this

research. The contents in such methods are determined by trainees, who also enjoy a moderate to high level of participation. The methods include the following:

Structured discussions: Conversations between trainees aimed toward specific learning objectives. Such objectives should be clearly announced in advance. The trainer may require some preparation for leading the discussion, both in terms of the topic, e.g. leading questions, and the facilitating techniques used to re-stimulate the discussion.

Brainstorming: Although it will be discussed in more detail in section 2.7, it is important to highlight that when used as a training method, this specialised form of discussion enables the trainer to train people “*to listen positively to the ideas of others and refrain from negative comments that might cause the creative process to run dry*” (Laird et al., 2003, p. 166).

Case studies: Participants receive a description of a problem situation and make recommendations, bringing the discussion to a realistic level. The trainer controls issues such as the amount of detail provided, description of task and desired outputs, time limits, etc. (Laird et al., 2003, p. 167-170). Particular types of case studies in the context of training methods include:

- *Action mazes:* the training group takes a decision and the trainer supplies the consequences of that decision, leading to the next stage of the case study.
- *Incident process:* participants have too little information to reach a decision and the trainer reveals the data only when asking specific questions to which the datum is relevant.
- *Jigsaws:* Participants put pieces together to complete an integrated picture, and the reasons and relative merits of each pattern are then discussed (Laird et al., 2003, p. 170).

In terms of the limitations in this field Cooke (1999) argues that unlike performance-critical applications such as expert systems, training requires more attention to issues such as the psychological validity of the knowledge, which may impact the extent to which the newly acquired knowledge is applied in the context of the organisation. Other authors refer to the difficulties in measuring the impact that the training may have

in the business as one of its limitations (Laird et al., 2003; Noe, 2008; Swanson and Holton, 2009).

Evaluation of success of knowledge transfer in the field of training and development

Evaluation of knowledge acquisition by individuals and groups in this field is embedded in the evaluation of the training programme itself. The method for evaluation of training programmes acknowledged as “the traditional approach” was established by Kirkpatrick in the 1960s (Kirkpatrick, 2005) and focuses on measuring success at four levels that address, respectively:

1. Participants’ reaction to the training programme
2. Participants’ learning as a result of participating in the training programme
3. Behaviour change as a result of the participation in the training programme
4. Organisational results

It could be argued that measurement of knowledge acquisition takes place fundamentally during the second stage of Kirkpatrick’s evaluation model. In addressing this stage, Kirkpatrick (2005, p. 43) provides guidelines that include:

- Evaluate knowledge, skills and/or attitudes both before and after the programme.
- Use a paper-and-pencil test to measure knowledge and attitudes.
- Use a performance test to measure skills.
- Use the results of the evaluation to take appropriate action.

Similar to Kirkpatrick, Laird et al. (2003, p. 184-185) recommend the use of pre-tests that enable the learners to discover where they are in relation to the ultimate goals of the training programme, and also conducting a final examination. Both Kirkpatrick (2005) and Laird et al. (2003, p. 184-185) recommend carrying out an ongoing evaluation using questionnaires of the type Agree/Disagree as they can show how people have changed their positions on issues central to the training programme, and there are no “right or wrong” answers that may have a negative effect in the learning process.

Summary

The knowledge acquisition methods used within the training and development field have significant relevance in the development of a new proposal for KET in organisations. Particularly relevant in the context of this research have been those methods where trainees determine the contents of the training and then learn through an active participation in the training programme. These methods have provided significant input to the KET method proposed by this research both in terms of its structure and the role of training facilitators.

On a separate issue, Kirkpatrick's four levels model of evaluation is acknowledged as the established mechanism for evaluating success of training programmes. The levels of knowledge acquisition by participants are assessed by Kirkpatrick's model using qualitative methods. Furthermore, to a certain extent the four levels model seeks to evaluate the training programme as a whole, also covering its impact in the business.

2.5.2. Action learning

Action learning has been defined as an approach to working with and developing people (Yorks et al., 1999). The key to knowledge acquisition in action learning consists of using work on an actual project or problem as a learning mechanism. Participants in an action learning programme work in small groups to take action to solve a real problem and learn from that action, keeping the right balance of work and learning and often with the support of a learning coach (Iles, 1994). These actions take the form of a cycle that was defined by Revans (1982) as including the following steps: observation, provisional hypothesis, trial or experiment, audit, and review.

Miller (2003) reports as example of an action learning exercise based on a process of mutual learning within small 'sets' of managers from different areas of the same organisations, through application and reflection on a workplace problem. The exercise started with a seminar on performance management to motivate learning, which was followed by weekly meetings that sought to develop the outcomes of the seminar. Later, managers were required to pilot new performance management instruments with members of their teams. After 12 months of the new instruments being in use, an

evaluation and review were carried out involving the managers and other staff, as a mechanism of learning from their impact in organisational performance.

In addition to its focus on real problems, Dilworth and Willis (2003) highlight the emphasis of action learning on reflection, its reliance on collaboration, and the importance of dialogue as mechanisms for knowledge acquisition. These three issues become the main input of the field of action learning to the purposes of this research.

Limitations of the approach to knowledge acquisition within the action learning field in relation to the focus of this research

O'Neil and Marsick (2007, p. 126) argue that a group involved in an action learning project should be based on the greatest diversity possible. Such diversity includes backgrounds, work experience, age, gender, nationality and gender style. However, the same authors called for an effort not to include people who could be considered subject matter experts to avoid the problem of 'the expert solution' described by Revans (1982). O'Neil and Marsick (2007, p. 126) argue that "*when experts are part of the problem-solving group, members look to them for solutions rather than learning and discovering fresh solutions on their own*". Although the problem of 'the expert solution' is closely related to the notion of learning by doing work on real problems, it raises awareness of the importance of a balanced participation in a KET exercise, where practitioners acknowledge the role of experts while also feel able to contribute to solutions with their knowledge and to challenge the experts' views when appropriate.

Dilworth and Willis (2003) argue that the main limitations of the knowledge acquisition process within action learning lie in the stresses and demands that an action learning project can impose on participants (p. 131).

Vince (1996, p. 119) argues that action learning helps learners think about experience and avoid and deny the emotional and political aspects of the knowledge domain. Learning, according to Vince, needs to consider not only the experience but also the rational, emotional and political issues that characterise the knowledge area. These issues are not often mentioned during the action learning process.

Evaluation of success of knowledge acquisition within action learning

Similar to other training and development strategies discussed in section 2.5.1, evaluation in this field focuses on the assessment of the action learning programme, which also covers the analysis of changes in individuals' knowledge.

Perhaps with more emphasis than other training and development strategies, O'Neil and Marsick (2007, p. 126) point out that action learning co-designers use Kirkpatrick's framework (Kirkpatrick, 2005) for evaluation of their programs, with particular emphasis on participants' reaction and satisfaction.

Summary

Action learning as a technique for development of people's skills seeks to build on the knowledge of participants rather than eliciting knowledge from some of them and transferring it to others. The way action learning approaches knowledge acquisition makes of it a significant source of input for this research. The key lessons to be learned by this research from the field of action learning are related to its emphasis on reflection as part of the learning process, its reliance on collaboration, and the importance of dialogue as mechanisms for knowledge acquisition.

Other issues to consider from this field include:

- A new approach to knowledge elicitation from experts and its transfer to individuals and workgroups across the organisation should avoid the learning by solving problems strategy.

The strategy of learning by solving real life problems that characterises the action learning field does not benefit from including individuals who are acknowledged as experts in the field. Instead, it is designed for people with relatively similar degrees of expertise.

Additionally, the stress and demands inherent to such a strategy places additional limitations to the knowledge acquisition process.

- The characteristics of knowledge may also become a limitation to the knowledge acquisition process in this field.

In terms of the evaluation of knowledge acquisition, the main lesson learned from the action learning field is that evaluation relies on the use of Kirkpatrick's four levels model, which emphasises the combination of qualitative and quantitative measures.

2.5.3. Social software

The term 'social software' is used to refer to a group of Web projects and services that during the past decade became perceived as especially connective (Alexander, 2006). However, the idea behind it dates as far back as the 1960s and Licklider's thoughts on using networked computing to connect people in order to boost their knowledge and their ability to learn (Licklider, 1960; Licklider, 1965; Licklider and Clark, 1962; Licklider and Taylor, 1968). Examples of social software include weblogs, wikis, trackback, podcasting, videoblogs, and social networking tools like MySpace and Facebook.

Social Software and knowledge transfer

Social software becomes a topic of interest for this research since some of these tools have been used as a medium to support knowledge acquisition processes in the workplace. They have often been implemented as part of wider KM initiatives in the hope that individuals in the workplace will be able to acquire knowledge that has been made available using these tools. Such a view is one of the best examples of the technology-based approach to KET described in chapter I, section 1.3.2.

Although different social software has been used to support KET mechanisms, many applications of weblogs and wikis have been found at an organisational level. This section will discuss three of these, assuming that the issues raised by their authors are representative of most applications of social software as a medium to aid KET in the context of organisations.

Weblogs and Wikis: In a nutshell, weblogs and wikis are social software that allow users to freely create web content in the form of documents using a web browser.

- In order to address the issues related to knowledge elicitation from experts and teams, the transfer of that knowledge to others, and issues related to motivation and trust of all organisational participants, Ras et al. (2005) suggested combining existing KM systems with the use of weblogs and wikis.

According to the approach suggested by Ras et al. (2005), a person within the organisation would play the role of a 'knowledge broker' in order to encourage and support the use of such weblogs and wikis by organisational participants. A 'specialised team' (p. 401) would then observe individuals' contributions to the social software in order to extract the relevant ones for storage in a KM system.

The solution proposed by Ras et al. (2005) does not address the knowledge elicitation problem. Nor does it concentrate on how such knowledge would be transferred to individuals. This solution assumes that knowledge has been elicited from experts, focuses on entering it into a KM system and is not concerned with whether and how that knowledge will be acquired by others.

- Rech et al. (2006) describe a methodology for knowledge transfer and reuse using wikis.

Their methodology is based on the analysis of the organisation's socio-technical infrastructure to then design, implement and introduce a wiki-based system tailored to the characteristics and needs of the organisation, its projects, and the target group(s). The resulting wiki is called a KM system and their authors concluded that the larger the organisation, the more probable it is that the knowledge in the wiki-based system is used by individuals.

- Having studied the need for knowledge sharing between Cranfield University postgraduate students, a wiki was developed by a team that included the author of this dissertation. As it was described by as described by Garcia-Perez and Ayres (2010), success of that software as a KET initiative ephemeral.

Limitations of knowledge transfer when using social software

Because social software is often used as a mechanism to support KET as part of wider KM strategies, their analysis overlaps with what has already been discussed in section 2.3.4 in relation to technology-based KM systems. Particularly relevant to the context of this research are the limitations by Rech et al. (2006) in relation to the characteristics of the knowledge stored in social software. These include:

- Issues generated by the volume of the contents

As the content gets larger and larger over time and subsumes more and more information, the system stores too long or redundant information about a particular topic, multiple pages are used to describe one topic that are not reusable for other knowledge descriptions, and many pages of information have to be read for users to understand a particular issue.

- Issues related to maintaining the quality of the knowledge

Multiple versions of the same information may be stored in the system. As a result, some of these may be considered as low value and not reused. The knowledge that is not used anymore may become undiscoverable by the users when it is archived.

Evaluation of success of social software as knowledge elicitation and transfer tools

Sitzmann et al. (2006) have argued that the rush to use the web for issues such as knowledge acquisition preceded the availability of empirical evidence of its benefits. These authors analysed qualitative data extracted from research reports written by participants on a number of case studies on the use of social software in training programmes. Sitzmann et al. (2006) concluded that not always the implementation of social software in the particular area of web-based instruction resulted in learning and retention, was well received by users, and was cost-effective.

Although many authors argue that they were able to evaluate the success of their approach to the use of social software as a KET technique, often the details of how the evaluation was carried out are not provided. That is the case of Rech et al. (2006), who mentioned the advantages and limitations of a system without providing any information describing how such a system was evaluated.

Summary

Although the use of social software as a KET technique overlaps with other technology-based approaches within the field of KM and training and development programmes, lessons have been learned from its analysis. As in KM systems, organisations using social software often place too much emphasis on the technology and the methodological issues are not addressed. As a result, issues related to the characteristics

of the knowledge, the time and effort required to use and contribute to the technology, and the required critical mass and individuals' motivation affect the long term value of the social software.

In terms of their evaluation as KET techniques, the literature suggests that not all organisations take the time to assess the value of this type of technology. Others report the results of the evaluation without referring to the process and tools that led to their findings. The most relevant to the purpose of this research have been those reports that outlined the mechanisms by which the social software were evaluated. In looking at these, the author found that collecting and analysing a combination of quantitative and qualitative data was used as an approach to evaluation by many researchers in this field.

2.6. Other relevant areas for the elicitation and transfer of knowledge

2.6.1. Introduction

There are other areas that have influenced the design, implementation and validation of the approach to KET proposed by this research. Among those, the inputs from two areas become significantly relevant. These are facilitation of group meetings, in particular focus group interviewing and brainstorming sessions, and the use of models and modelling to support KET. This section will outline the main issues that determine the contribution of both areas to the findings of the research reported in this dissertation.

2.6.2. Facilitation of group meetings

Introduction

Two reasons have made facilitation of group meetings a relevant area for the purposes of this research. These are:

1. The role of facilitators or moderators in many of the knowledge elicitation and knowledge transfer techniques reviewed in sections 2.3 to 2.5.
2. The importance of group-based approaches to KET for many domains concerned with knowledge elicitation and knowledge transfer, in particular for those reviewed in sections 2.4 and 2.5.

An additional motivation to carry out this review was the fact that although facilitated group-based techniques are a successful approach to KET in different domains, these are not widely used in the field of KM.

A key factor defining facilitated group-based techniques is that they take place during meetings. Bostrom et al. (1993, p.148) define a meeting as follows:

“a goal- or outcome-directed interaction between two or more people (teams, groups) that can take place in any of four environments (same time/same place, same time/different place, different time/same place, and different time/different place)”.

The new approach to KET proposed by this research learned in particular from two techniques that involve facilitation of the dynamics of a group of people that meet at the same time in the same place with the aim of eliciting some type of knowledge from some or all of the group members. These are focus group interviewing and brainstorming sessions. The remainder of this section will review the main issues related to both techniques.

Focus groups

A focus group has been defined as a group of individuals who discuss a particular topic under the direction of a moderator who promotes interaction and assures that the discussion remains on the topic of interest (Stewart and Shamdasani, 1990, p.10). The usefulness and validity of a focus group is affected by the extent to which participants feel comfortable about openly communicating their ideas, views or opinions. The review of the literature on the knowledge elicitation and knowledge transfer problems suggested that such an open communication of knowledge is one of the key drivers to a successful KET process.

The literature on group dynamics refers to the importance of the variables that influence individuals' comfort zones, as intrapersonal, interpersonal and environmental variables (Morgan, 1997).

Individual participants in a KET exercise are often determined by the needs of an organisation, i.e. an expert moving to a different position, a visiting expert, individuals with specific roles etc. Thus, an organisation seeking to run a KET exercise may have

little control over the intrapersonal and interpersonal variables related to the potential participants in such a project. Environmental variables, however, can be better controlled by the organisation.

Environmental variables that have been studied as part of the validation stage of this research include:

- The room size: group interaction is more intense in small rooms than in large rooms (Lécuyer, 1975).
- Spatial arrangements and territoriality: Participants who are made to sit too close to others may feel uncomfortable and tend to act in a way that affects their communication with the group, e.g. withdrawal from the discussion or a tendency to attend to the facilitator rather than the group as a whole (Stewart and Shamdasani, 1990, p.49).

There are also references in the literature to the importance of the role of a facilitator or moderator in such meetings. For example, Bostrom et al. (1993, p.146) argue that the quality of the group session is predominantly dependent on the facilitator.

A facilitator or moderator is often a stranger and is entrusted with the task of creating rapport and motivating participants to share their knowledge, eliminating much of the distraction associated with the group developing its own pattern of leadership (Stewart and Shamdasani, 1990, p.10). In a KET exercise the role of a facilitator would enable the group to learn from the experts without falling into the problem of 'the expert solution' described by Revans (1982). In the context of this research, maintaining control of the group by seeking that all members contributed actively to the discussion and avoiding that the group is dominated by one member who could often be an expert was one of the key lessons learned from focus groups in terms of facilitation. Additionally, facilitation of focus groups contributed to the issues of direction, structure and use of discussion aids Schwarz et al. (2005) during KET exercises.

Brainstorming sessions

Brainstorming refers to a group interaction technique used for increasing creativity in organisations in tasks such as developing products, overhauling business systems, and improving manufacturing (Osborn, 1963). The basic rules that support idea generation in a brainstorming session include, according to Wilson (2006):

- Allowing participants to say whatever comes to their minds.
- Refraining from evaluating ideas until everyone has had their say.
- Vote on ideas once they all have been presented.

Research conducted by Offner et al. (1996) has suggested that brainstorming is more effective when sessions are led by a trained facilitator.

As a group technique, brainstorming has a number of significant commonalities with focus groups. The common issues include the potential effects of the variables that influence individuals' comfort zones in the outcomes of the group meeting. These variables cover intrapersonal, interpersonal and environmental issues, described by Morgan (1997) as analysed in section 2.6.2.

What makes brainstorming sessions different from other group techniques is its focus on idea generation, i.e. on producing new ideas, without a rigid structure for the session, rather than eliciting specific knowledge from participants.

Research conducted by Sutton and Hargadon (1996) becomes particularly relevant for this research. These authors found evidence supporting six major consequences of brainstorming for organisations, which make of brainstorming a relevant field for the development of a new approach to KET by the research reported in this dissertation. The six consequences listed by Sutton and Hargadon (1996, pp. 696-698) are:

- *Supporting organisational memory.* The organisation's products are brought to the brainstorming session for analysis and all participants learn from it.
- *Providing skill variety.* Applicability of the same information in different products emerged as a result of brainstorming sessions.
- *Supporting attitude of wisdom.* Different people contribute from different viewpoints to the development of the same idea.

- *Creating status auctions.* After brainstorming sessions, individuals who provided significant input gained recognition.
- *Impressing clients.* The organisation gained reputation by discussing specific findings of brainstorming sessions with some clients.
- *Providing income.* As brainstorming time was billed to the client, the organisation found in it a positive way to benefit itself and the clients.

Additionally, Sutton and Hargadon (1996, p.699) argue that brainstorming is

“an efficient way to disperse design knowledge among engineers, reminding experienced designers and teaching newcomers about which solutions had been considered in the past and spreading information about solutions that are new to the company”.

This matches the aims that a Gas Turbine Manufacturing company involved in the early stages of this research sought to achieve by engaging in a KET collaboration with the author of this dissertation.

Summary

The main contribution of facilitated group-based techniques such as focus group interviewing and brainstorming sessions to the domain of KET in organisations consists of:

- The importance of considering the issues that influence individuals' comfort zones, i.e. intrapersonal, interpersonal and environmental variables, as these affect the ability of individuals to openly communicate their knowledge.
- The importance of the role of a facilitator or moderator in group-based techniques as an enabler of learning processes through an active control of the group dynamics.
- An open communication of ideas where contributions are not restricted to specific group members may have a significant impact in sharing knowledge.

2.6.3. The use of models and modelling in KET

Introduction

Another topic that is closely related to the definition, implementation and validation of the approach to KET proposed by this research is the use of models and the process of creating models as aids to the processes of eliciting knowledge from experts and transferring it to the less experienced.

As early as 1993, in a reference to the development of knowledge-based systems, Ford and Bradshaw (1993, p. 1) stated that “*knowledge acquisition is a modelling process, not merely an exercise in ‘expertise transfer’ or ‘knowledge extraction’*”. Different attempts have since then been made to use models and modelling in relation to KET. Given their relevance for this research, this section will review, in a chronological order, some of the relevant attempts as reported in the literature.

Modelling as an aid to KET

In an attempt to provide a definition of the term *model* that was close to its usage in the knowledge acquisition literature, Gaines (1993, p. 53) chose the following from the Webster’s dictionary:

“A model is a representation, generally in miniature, to show the construction or serve as a copy of something”.

However, a mere representation is not necessarily a model. For it to be a model, argues Gaines (1993, p. 53), the representation should be relatively minimal in serving a purpose that is related to what is represented.

Modelling has been defined by Maria (1997, p.7) as “*the process of producing a model*”. An important issue defining modelling as a process is the validity of the model created.

Ford et al. (1993) used the concept of *knowledge acquisition through modelling* to refer to a “*cooperative enterprise, in which the knowledge engineer and an expert collaborate in constructing an explicit model of problem solving in a specific domain*”. In their view such a model would be later used in the development of a knowledge-based system and could become a useful asset for individuals and the organisation.

Concept mapping has been described by Hoffman (2002) as a method by which people's ideas about a knowledge domain are described in a graphical form. Coffey and Hoffman (2003), and Hoffman and Coffey (2004) referred to concept mapping as a mechanism for eliciting knowledge based on modelling. A concept map is defined by Novak and Gowin (1984, p.15) as a graphical representation of “*a set of concept meanings embedded in a framework of propositions*”. An example of a concept map for engineering is included in figure 2.2.

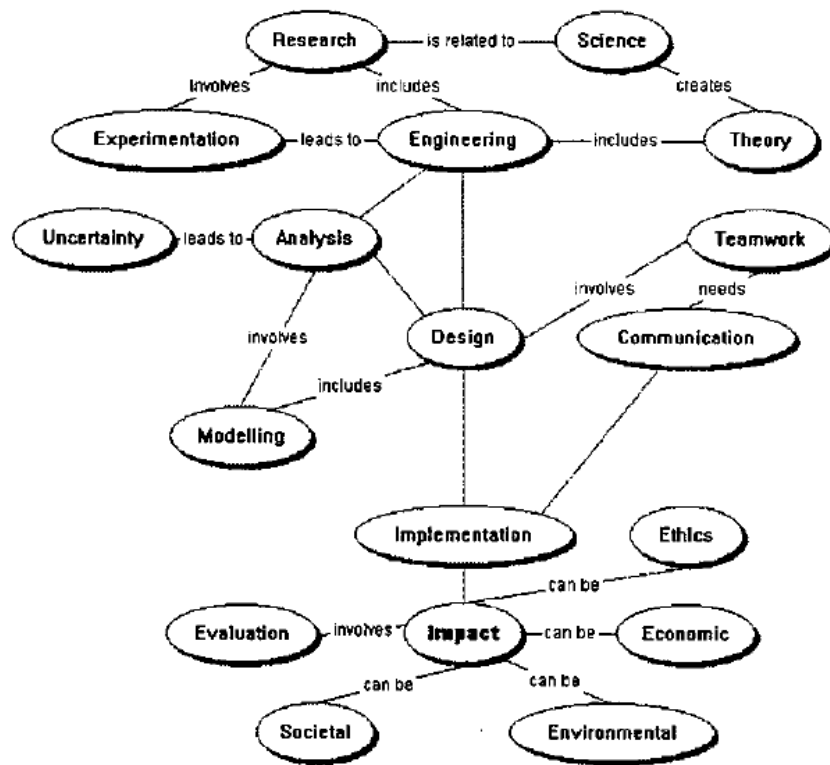


Figure 2.2. An example of a concept map for engineering - from Turns et al. (2000, p. 164)

The strength of concept mapping, Hoffman (2002, p. 3) argues, lies in generating models of domain knowledge. According to Hoffman, concept mapping can be used to create diagrams that look like flow diagrams or decision trees. Hoffman used concept mapping as a method for eliciting and modelling knowledge from domain practitioners, in order to create large number of propositions covering the domain knowledge (p. 1), which would then become the basis for the development of a knowledge-based system.

On the basis of previous work on concept mapping carried out by Coffey and Hoffman (2003), Basque et al. (2004) developed a software tool for modelling, called MOT (an acronym for “*Modélisation par Objets Typés*”), that would allow bringing experts and novices together in a technology-based knowledge sharing session based on modelling. Although a successful implementation of this approach in a particular organisation was reported by Basque et al. (2008, p. 375), its authors acknowledged that the technology imposes constraints to the types of knowledge that can be elicited. They argued that whether the method would actually result in transfer of knowledge was something still to be studied. Also, Basque et al. (2008, p. 376) acknowledged that their technique would face the same issues that most technology-based approaches have had to deal with, including expert’s motivation to share their knowledge, and the individual’s spatial or verbal skills or their cognitive style. Other issues affecting success of the KET in such an approach, as mentioned by its authors include:

- The degree of active contribution of each participant involved in the activity.
- The training required for conducting the knowledge modelling, increased by the expertise required to handle the MOT software.
- The knowledge representation language used by the MOT software.

Thus, although there are lessons to learn from the use of modelling to support KET, the approaches reported in the literature are dominated by the use of technologies and could not avoid the limitations imposed by these.

2.7. Summary of lessons learned from the literature

A review of some of the key approaches to knowledge elicitation and knowledge transfer reported in the literature over the last 30 years suggests that:

- There has been a wide range of knowledge domains influenced by KET techniques through areas such as expert systems and KM.
- Although an emphasis on technology-based solutions is prevalent, there is concern about the limitations of technology-based approaches and awareness of the importance of considering people-based approaches to knowledge elicitation and knowledge transfer.

- Facilitation has played a key role in knowledge elicitation and knowledge transfer processes in different areas.
- Knowledge elicitation and knowledge transfer strategies have often used one or more techniques to achieve their aims, depending on the nature of the knowledge being addressed.

The limitations of the techniques for knowledge elicitation and knowledge transfer studied can be summarised as:

- Issues determined by the characteristics of the knowledge to be elicited and transferred, such as its quality, ease of learning and applicability.
- The demands of the KET processes in terms of time, skills and other resources.
- Problems related to the selection of experts and their ability to contribute their knowledge.
- Motivational issues related to the elicitation of knowledge from experts and its acquisition and application by individuals and workgroups.

These issues acquire significant relevance in areas that have focused on implementing technology-based approaches to KET.

Some techniques for eliciting knowledge from individuals in groups have been applied in different areas. These include approaches to training and development such as action learning. Given the impact that these areas have had in organisational development, it seems appropriate to implement face-to-face, group-based techniques in knowledge management, where this does not seem to be the most commonly used approach to KET.

On this basis the author has reviewed two areas that have the potential to inform a new approach to KET. These are the field of facilitation of group meetings and the use of models and modelling to support KET.

The main contributions of facilitated group-based techniques such as focus group interviewing and brainstorming sessions to the domain of KET in organisations consist of:

- The study of issues that influence individuals' comfort zones, i.e. intrapersonal, interpersonal and environmental variables, as these affect the ability of individuals to openly communicate their knowledge.
- The definition of the role of a facilitator or moderator in group-based techniques as an enabler of learning processes through an active control of the group dynamics.
- The mechanisms to support an open communication of ideas where contributions are not restricted to specific group members, regardless of their level of expertise.

Modelling has been used to aid KET in some areas over the last two decades. However, attempts to use modelling in this context have been limited by at least one of the following issues:

- Only knowledge engineers and experts have been included in the KET process.
- When other practitioners have been part of the process, their interaction with experts has been mediated by a computer program.

Additionally, instead of the elicitation of experts' knowledge and its transfer to other practitioners, the ultimate aim of the modelling in all the attempts reviewed has been the development of a working system.

In terms of evaluation of knowledge elicitation and knowledge transfer, some research reports describe a combination of quantitative and qualitative data collection methods used to measure the benefits for organisations. This is often carried out by following the Kirkpatrick (2005) four levels model of evaluation.

The remainder of this dissertation describes how the lessons learned from the literature were applied in the design, application and validation of a new approach to KET based on facilitated, collaborative modelling of domain specific knowledge by experts and practitioners. The new approach is presented in chapter IV, whilst its applications in the field and assessment are discussed in chapters V and VI respectively.

Chapter III

METHODOLOGICAL APPROACH TO CONDUCTING THE RESEARCH

The human nature of knowledge has several implications in the different ways that processes such as knowledge elicitation from experts and its acquisition by stakeholders can be studied. The purpose of this chapter is to help the reader understand how the researcher will be able to prove that facilitated collaborative modelling of domain-specific knowledge can be used as a mechanism to enable knowledge elicitation and transfer.

This chapter will therefore outline the methodological choices which have been made in the light of the research problem addressed and its context, as described in chapter I. In doing this, the chapter seeks to outline the research strategy, design and methods adopted to conduct this study, and also the author's awareness of their strengths and weaknesses. The chapter will also enable the reader to understand the feasibility and competence of the research approach adopted.

3.1. The need for a methodology chapter

Key issues for this research, as discussed in chapters I and II, include knowledge, knowledge elicitation and knowledge transfer. In order to understand how these issues have been studied it is important that the overall strategy adopted for the data collection and analysis is outlined. This will enable the reader to assess the relevance of the data collected and their analysis for the purposes of addressing the research questions.

Following the viewpoints outlined by Silverman (2005, p.234), this chapter will provide answers to the following questions:

1. What are the theoretical assumptions that shaped the data collection and analysis reported in this dissertation?

2. What were the factors that made the author choose to work with these particular data?
3. How did the overall strategy adopted and the research design and techniques used by the author affect the conclusions of the research and how can the author still generalise from his analysis?

These questions will be partially answered in sections 3.3 and 3.4 in this chapter. Chapters V and VI will then focus on a detailed description of data collection and analysis processes. Thus, these topics will be addressed in the body of this thesis as follows:

- Sections 3.3 and 3.4 will define the general approach used by the author to study the KET problem in organisations.
- Chapter V, section 5.1, highlights the specificities of the data collection process before reporting the applications of the new approach to KET in the field.
- Chapter VI, section 6.1, describes the specific analytic strategy used to assess the new approach to KET, based on the data collected.

3.2. Key concepts supporting the conduct of this research

It would be difficult to define the author's theoretical assumptions and the main issues affecting the data collection and analysis processes without referring to terms such as the author's *mental model* of research; the *concepts* related to addressing KET in organisations; *theories* supporting the study of such concepts; *hypotheses*; *methodologies* and *methods* used. A review of the literature on research methods shows that there is no consensus as to how some of these terms are understood and used. Therefore, this section will aim at making it clear for the reader how these terms have been related to the context of this research and how they are to be understood in the remainder of this dissertation.

Mental models

Investigating a research problem is in most cases influenced by the researcher's understanding of the reality surrounding such a problem. Such an understanding of reality is referred to in the literature as *models* or *mental models*. The author adheres to

Senge's (1993, p. 487) view of mental models as “*deeply ingrained assumptions, generalizations (sic), or even pictures or images that influence how we understand the world and how we take action*”.

Models, also referred to as research paradigms, provide an overall framework for how reality is looked at (Silverman, 2005, p. 77). Therefore, a description of the model underpinning a particular research will tell the reader:

- What reality is like for the researcher(s) who conducted the particular study, and the basic elements that their understanding of reality contains. This is also known as the *ontology* of the research (Bryman and Bell, 2007, p. 5).

A description of the author's mental model will enable the reader to understand the author's approach to study organisations as social entities, in order to answer questions such as the following: Is the elicitation of knowledge affected by issues external to the individuals involved in the process?

- What a particular researcher acknowledges as the nature and status of knowledge. This is also known as the *epistemology* of the research (Bryman and Bell, 2007, p. 16).

A description of the author's mental model will enable the reader to understand whether the researcher recognises that qualitative data such as individuals' perceptions could be regarded as acceptable knowledge in the process of addressing the research questions.

Concepts

From the authors' mental models emerge the *concepts* to be studied. Blumer (1954) refers to concepts as providers of a general sense of reference and guidance in approaching empirical instances. Blumer (1954) argued that concepts give a very general sense of what to look for, also acting as a means for uncovering the variety of forms that the phenomena to which they refer can assume.

Theories

Research ideas and their related concepts drive the study and development of *theories*. A theory is defined by Silverman (2005, p. 78) as an arrangement of a set of concepts with the aim to define and explain a phenomenon. By provoking ideas about the

presently unknown, argues Silverman, theories provide the impetus for research. They are living entities that are developed and modified by research. Myers (2009, p. 40) argues that a good theory is one that helps the researcher to understand the meanings and intentions of the people being studied. In that respect, theories can never be disproved but only found to be more or less useful.

Hypotheses

A *hypothesis*, according to Myers (2009, p. 259) is a testable proposition that purports to explain a phenomenon. Hypotheses are often produced during early stages of the research and can and should be tested in such research.

Methodology

A *methodology* or research strategy defines a general orientation to the conduct of business research (Bryman and Bell, 2007, p.28) or simply how a phenomenon will be studied. A broad distinction is often made between quantitative or qualitative methodologies.

Research methods

Finally, a *research method* is defined by Bryman and Bell (2007, p. 40) as a specific technique for collecting data. Research methods can involve both quantitative and qualitative techniques and instruments such as statistical correlations, questionnaires, or participant observation.

The relation between models, concepts, theories, hypotheses, methodology and methods has been set out schematically as follows:

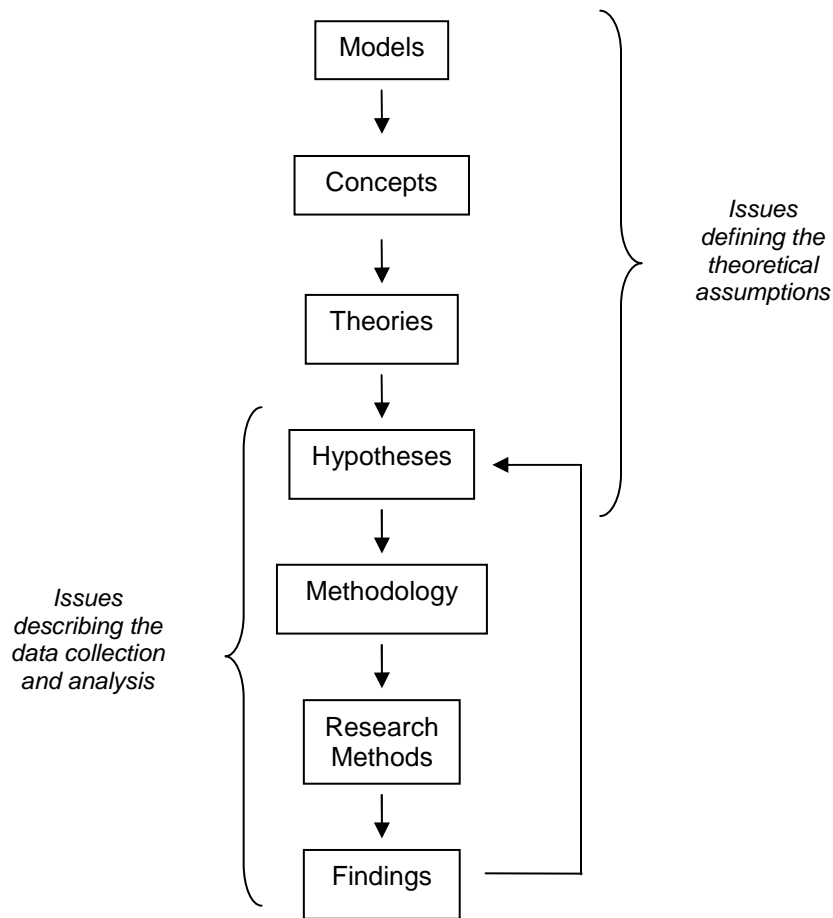


Figure 3.1. The relation between different levels of analysis in a research – adapted from Silverman (2005, p. 79)

3.3. Theoretical assumptions made in the conduct of the research

The theoretical assumptions implicit in this research were determined by one or more of the following:

- The author's mental model (referred to as research paradigm in this section).
- The research ideas in the field of KET that acted as a starting point of the research.
- The concepts deriving from such ideas.
- The theories supporting these, from which a hypothesis was defined.

This section will define the author's theoretical assumptions by outlining each of these components.

3.3.1. The research paradigms

This research is primarily concerned with the elicitation and transfer of knowledge in organisations. The author understands organisations as socially constructed bodies, built up from the perceptions and actions of individuals. This view, according to Gergen and Thatchenkery (2004) has an effect in the form that research is conducted, the theoretical commitments of the author and the ways practices within the workplace are understood. The author adheres to the notion of individuals as rational agents whose knowledge and abilities determine the organisation's competencies and success drivers. In the author's view, individual managers' actions can have a significant effect in individuals' performance and also help creating the optimal balance between the organisation and environmental conditions. The author's view is supported by authors in the field of social studies such as Argyris (1996), Eastman and Bailey (1996), Gergen and Thatchenkery (2004) and Jacobs and Heracleous (2006).

Those assumptions about the role of individuals within organisations made the author believe that knowledge, knowledge elicitation and knowledge transfer (i.e. the key issues ingrained in the research problems outlined in chapter I) can only be measured through the interpretive understanding of the meaning of such concepts for organisational participants. This view was later found to match Bryman and Bell's (2007, p. 18) notion of the need to carry out the task of 'causal explanation' with reference to the 'interpretive understanding of social action' rather than to external forces that have no meaning for those involved in that social action.

3.3.2. Research ideas

The work carried out during early stages of this research helped the author understand the importance for organisations of overcoming the limitations of current approaches to KET. Such an understanding led to the definition of the main research question. However, other ideas emerged from the work carried out during early stages of the research. These included the following:

- Knowledge elicitation and knowledge transfer are processes that can benefit from the lessons learned in existing facilitated group collaboration techniques.
- Knowledge transfer has significant commonalities with the concept of learning.

- Modelling a specific topic within a knowledge domain is an exercise that entails collaboration and could potentially foster learning by and from those individuals involved.
- Individuals to be involved in the modelling process could include experts and other practitioners carefully selected by the organisation according to its knowledge needs.
- If there are no restrictions in the representation schemes that could be used for modelling, then many types of knowledge could be effectively elicited from experts and transferred to other practitioners within the organisation using this approach.

3.3.3. Research concepts

The key concepts that became the building blocks of the set of ideas outlined above and therefore represent the points around which this research was conducted included *knowledge, knowledge elicitation and transfer, group dynamics, facilitation and modelling*. Supported by the review of the literature reported in chapter II, these and other concepts became part of the main research problem. As such, they were combined to form the secondary research questions presented in chapter I.

3.3.4. Theories

The focus of this research was defined by combining a review of relevant literature with empirical work on the research topic of KET. In this sense, the relevant background literature on the existing approaches to KET techniques in different areas and their limitations were the equivalent of theories supporting the identification and study of the research problem.

This view is supported by Bryman and Bell (2007, p. 7-15), who discuss the limitations of theories, both grand theories and middle-range theories, to support the validation of research findings. Bryman and Bell (2007, p. 10) argue that instead of theories, the literature can inform the generation of research questions in relation to what the authors perceive to be a relevant research topic, and

“the data collection and analysis are subsequently geared to the illumination or resolution of the research issue or problem that has been identified at the outset. The literature acts as a proxy for theory. In many instances, theory is latent or implicit in the literature.”

3.3.5. Hypothesis

The ideas outlined above were arranged around the main research question and, informed by the relevant background literature, the following hypothesis was defined:

Facilitated collaborative modelling of domain-specific knowledge has the potential to foster the processes of knowledge elicitation and knowledge transfer in organisations, overcoming some of the main limitations of existing approaches.

3.4. Methodological approach to data collection and analysis

The data collection and analysis processes carried out in order to test the hypothesis above were shaped by different factors including the theoretical assumptions of the researcher and also practical issues that will be discussed in the body of this dissertation.

This section uses the terms methodology or research strategy, research design and research methods as defined in section 3.2, to describe the approach taken to collecting and analysing the data. More specific details on the processes of data collection and data analysis are provided in chapters V and VI respectively.

3.4.1. Methodology or research strategy

The nature of the research problem defined and the epistemological and ontological orientations of its study suggested that the research would be conducted by following a qualitative methodology or research strategy. The main reasons supporting this argument included, as outlined by Bryman and Bell (2007, p.28), the following:

- The research is not concerned with the testing of an existing theory as quantitative research does. In its relationship with theory, emphasis is placed on the use of existing theories already available in the literature relevant to KET.

Additionally, the research focuses on the generation of findings that are likely to contribute to the development of new theories related to how KET processes can be improved in organisations.

- The research has a preference for an emphasis on the ways in which individuals interpret concepts related to KET, such as value, currency, trustworthiness and applicability of knowledge.
- The research embodies a view of the social reality of organisations as a constantly shifting emergent property of individuals' creation through the application of their knowledge and skills.

3.4.2. Research design

The author sought to refine and validate the findings of this research by carrying out an intensive examination of a new approach to KET in the setting for which it had been designed: organisations. For every organisation involved in the research the author would design and prepare at least one distinct KET project. The project would then be implemented and relevant data collected. Such data would be analysed and the results reported first to the organisation and later in the form of a PhD thesis. This plan motivated the consideration of a case study as a research design, which would enable the author to provide an in-depth elucidation of the processes of knowledge elicitation and transfer by concentrating on their implementation in one or more organisations (Bryman and Bell, 2007, p. 62).

Case study was therefore chosen by the author as a research design, also based on three key issues outlined by Yin (2009, p. 3-13). These were:

- The *explanatory* nature and form of the research question:

'How can the limitations of existing approaches to knowledge elicitation and transfer in organisations be overcome?'

In addressing this question it was unlikely that the author would have to deal with mere frequencies or incidence of specific events. Instead, a study of links between individuals' participation in KET processes and their perception of issues such as learning was foreseen. Such operational links would need to be

traced over time in the particular context of the organisation where individuals carry out their knowledge activities.

- KET in organisations can be studied as these processes take place within a real-life context. In doing this, the author would gain access to a wide range of sources of evidence that include documents and artefacts, but also interviewing participants and observing the development of KET processes. Collecting data from different sources provides the opportunity to cross-check findings obtained by different approaches.
- Organisations do not provide a laboratory setting where the research could focus on one or two variables related to the KET processes and control all the remaining variables beyond the scope of interest. Knowledge has a human dimension and its related processes are influenced by many behavioural variables such as motivation, politics, etc. which are beyond the control and even access of the author.

Myers (2009) highlights some of the traditional prejudices against the case study method by highlighting terms such as ‘validity’ and ‘reliability’, which “*imply an objective reality independent of social reality*” (p. 78). Yin (2009, p. 15) mentions other common concerns about case studies, related to issues such as the basis that these provide for generalisation or the large amount of time they take and the volume of data they produce. In the author’s experience both the theoretical foundations imposed by the research context and the practicalities of its implementation imposed significant challenges, including:

- Demonstrating reliability, replicability and validity of the research findings. In order to arrive at reliable, valid and replicable findings the case study involved more than one knowledge intensive organisation. This decision was based in the argument that “*the evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust*” (Yin, 2009, p. 53).
- Collecting and organising a consistent set of data relevant for the purposes of the research. The author sought to minimise the extra effort required from participants during the data collection processes. Additionally, all the data

collected and reports written were organised taking account of its context, which was determined by the relevant case, dates, people involved and stages of the KET process related to each document produced.

- Finding organisations that were aware of their need for implementation of KET processes and were able to engage in collaboration with the researcher towards these aims. In order to gain interest of organisations, the author prepared what was considered by himself and his supervisor as an ‘interesting business case’. This was used to approach individual managers carefully selected from knowledge intensive organisations.
- Determining how many cases would provide the amount and quality of data that would be sufficient to validate the research findings.
- Engaging in successful collaboration with those organisations. Given the cost and risks associated to a joint venture between an organisation and the researcher in an attempt to study the KET problem, the author concentrated on achieving a successful outcome for both parties involved.

Those challenges suggested that the data collection would be an iterative process involving the researcher and practitioners acting together on a particular cycle of activities that included problem diagnosis, action intervention, and reflective learning. This was later found to be in line with the principles of Action Research as defined by Avison et al. (1999), who argue that in order “*to make academic research relevant, researchers should try out their theories with practitioners in real situations and real organisations*”.

Additionally, arriving at a convincing understanding of the context where KET took place by talking to people (Myers, 2009, p.5) required the author to explicitly work towards developing a number of people-related skills. Developing appropriate people-related skills was important in helping to set up and run appropriate exercises. An intense interaction with participants in KET projects as part of the research took the form of facilitating meetings and conducting interviews before, during and after such field work exercises.

Every effort was made to ensure that neither the traditional prejudices related to case study research nor the practical issues related to the implementation of the research affected the rigour and relevance of its findings. In doing this, emphasis was put on the validity of theoretical and methodological decisions made during the design of the research.

3.4.3. Research methods

One of the benefits of case study research is that it offers access to a wide range of sources of evidence that include documents and artefacts, but also interviewing participants and observing the development of KET processes. Therefore, for data collection and analysis strategies, authors such as Yin (2009) advocate using multiple sources of evidence, triangulating these data and using theoretical propositions from the research literature to guide the research (Myers, 2009, p.75).

This has been the basis for the author's approach to data collection. Different methods were used to collect data, a process that was informed by the research questions and the relevant background literature on KET. These methods included:

- Analysis of documents such as those related to the knowledge domains where KET took place, or reports from previous attempts to run KET projects within some of the organisations involved.
- Analysis of records from practitioners' dealings with specific issues relevant to the KET processes within their organisations.
- Interviewing individuals within the organisations involved in the research.
- Direct observation of KET processes and reactions from individual participants and managers during presentations of the outcomes of such processes.
- Use of physical artefacts such as flip charts, voice recorders and cameras.

Once the set of relevant data on each individual case study had been collected using different methods, the use of triangulation enabled the author to contrast all data collected on that particular case and create a short report that described the case from a wider perspective.

3.5. A plan for the conduct of this research

Once the research questions had been defined and the theoretical assumptions and issues affecting the data collection and analysis had been understood, it was necessary to have a plan for the investigation. Such a plan constitutes a research design and provides a framework for the collection and analysis of data. Kerlinger (1986, p. 279) describes a research design as

“a plan, structure and strategy of investigation so conceived as to obtain answers to research questions of problems. The plan is the complete scheme or program of the research. It includes an outline of what the investigator will do from writing the hypothesis and their operational implications to the final analysis of data”.

The research design outlined during early stages of the research was limited by the practical issues related to its implementation, e.g. establishing joint ventures with organisations that were still to be found, as described in this chapter. The design was therefore a live document that followed the structure in figure 2.2 and developed as new opportunities for collaboration emerged.

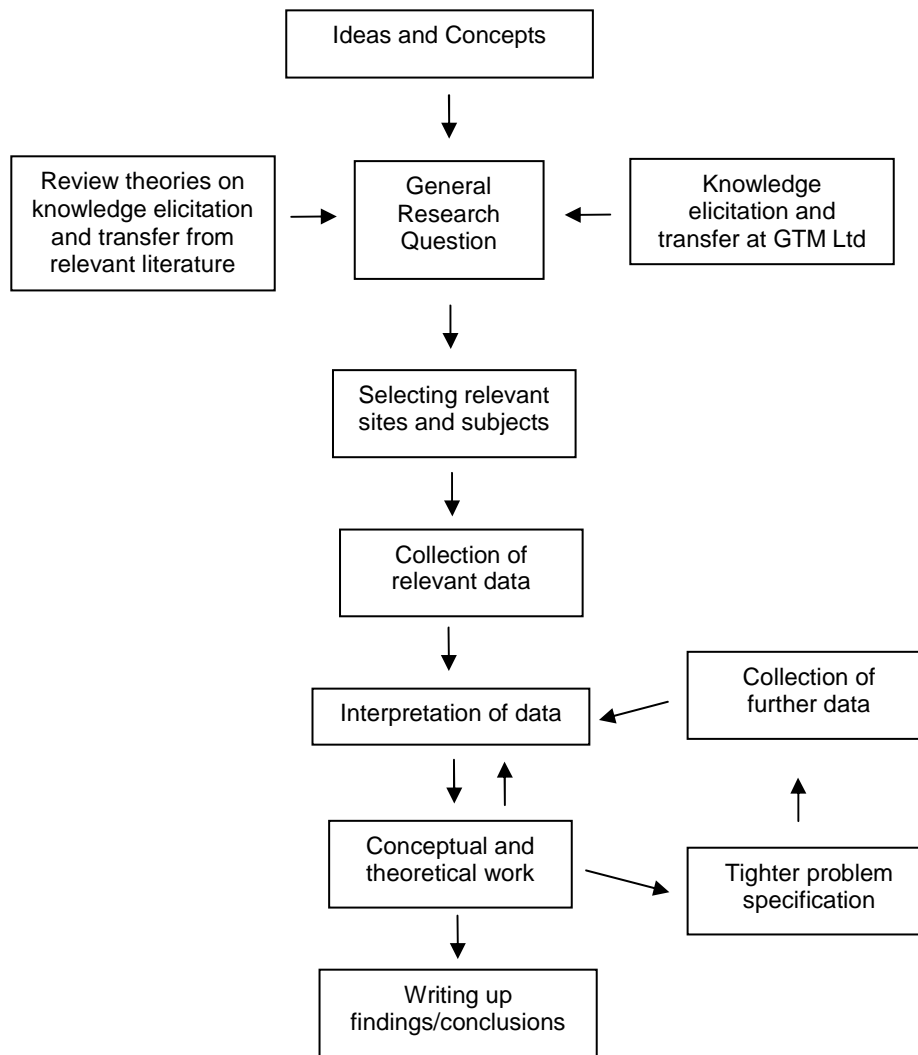


Figure 3.2. An outline of the main steps of the research – adapted from Bryman and Bell (2007, p. 406)

The collection of data through a multiple case study will be detailed further as part of chapter V.

The author sought to adhere to the general view of the research design as much as possible, and ensure that the practical issues related to its implementation did not affect the rigour and relevance of its findings. In doing this, emphasis was put on following the theoretical and methodological decisions made during the design of the research.

3.6. Potential effects of the researcher's values in the research findings

Given the theoretical and methodological issues underpinning this research, it is important to discuss the extent to which its findings may have been influenced by what Carroll and Swatman (2000) called "*the researcher's conceptual lens*". Gadamer (1985) used the term *historicality* to refer to how issues such as the researcher's culture and personal history could influence his/her reading of what individuals said. Other authors refer to the personal beliefs and the feelings of a researcher as his or her *values*.

As early as 1975 Gadamer (1975, p. 358) argued that hermeneutics, i.e. the study of interpretation theory, suggests that understanding always involves interpretation; and interpretation means using one's own preconceptions so that meaning of the object can become clear (Myers, 2009, p. 187). When the research involves organisations and people the researcher often becomes the main 'research instrument', and 'measuring' becomes 'interpreting'. In such circumstances it is not feasible to keep the values that a researcher holds away from the interpretation of what people say (Gadamer 1985; Berg, 2004; Bryman and Bell, 2007; Myers, 2009).

Bryman and Bell (2007, p. 30) go even further to argue that in research like that described by this dissertation the values that a researcher holds are not only expected to affect the research findings. Any other or all of the following aspects can be affected by the researcher's values without invalidating the research:

- Choice of research area.
- Formulation of research question.
- Choice of method.
- Formulation of research design and data collection techniques.
- Implementation of data collection.
- Analysis of data.
- Interpretation of data.
- Conclusions.

In the view of Miles and Huberman (1994, p. 8), interpretivist researchers have “*their own understandings, their own convictions, their own conceptual orientations*”. Interpretivist researchers are members of a particular culture at a specific historical moment and are therefore affected by what they hear and observe in the field, often in unnoticed ways.

The author acknowledges that his research interests, supported by his previous background and experience, were the starting point of this research into the knowledge elicitation and transfer problem. However, during the design and conduct of this research he remained aware of the importance of hermeneutic concepts and therefore sought to minimise the impact of his biography and prior knowledge on the credibility of the research findings. For example, any understanding of the organisations initially gained by the author (e.g. by reading documents such as newspapers reports or documentation of knowledge management projects within the specific organisations involved) was sought to be validated, improved and refined by interacting with organisational participants (e.g. through interviews, facilitation of knowledge elicitation and transfer exercises, etc) before any reference to specific facts was made. The aim of this was to avoid any false prejudices that could lead the author to a misunderstanding of facts.

Additionally, the author followed the expected ethical principles in its relation with organisations and with individuals as part of the research. Reciprocity was paramount, and therefore the researcher sought to communicate openly and honestly with the organisations involved in the research, and to provide them with every piece of data collected that could be of value for them. Every stage of this research was carried out in a planned, structured, documented and critical manner so that their outcomes remained valid for the purposes of the research.

Chapter IV

A NEW APPROACH TO KNOWLEDGE ELICITATION AND TRANSFER IN ORGANISATIONS

This chapter presents a new approach to knowledge elicitation and transfer in organisations, based on facilitated collaborative modelling of domain-specific knowledge. This approach has been developed in an attempt to overcome some of the main limitations of existing techniques for knowledge elicitation and transfer as identified in the relevant literature. The fundamentals of the new approach are preceded by a summary of its empirical origins and theoretical foundations. A method that organisations can use to implement the proposed approach is described, followed by details of a sample application of the method in a real organisation.

4.1. Definition of the new approach to knowledge elicitation and transfer

4.1.1. The empirical origins of the new approach to KET

A significant milestone that marks the beginning of the development of the new approach to knowledge elicitation and transfer in organisations was the collaboration with a gas turbine manufacturer which will be referred to as GTM Ltd hereafter. GTM Ltd designs, manufactures and commissions gas turbines. The company also provides supports to its customers in the service of the products that are being used in the field. In its interaction with customers, the GTM Help Desk has developed significant expertise in the operation of gas turbines. That expertise was considered as an increasingly important component in the design and manufacture of new equipment.

The collaboration with GTM Ltd aimed at eliciting knowledge from Help Desk experts and transferring it to engineers from other departments. In an attempt to also provide GTM with a short-term tangible outcome as a result of the collaboration, the researcher

agreed to develop a system that could be used to support the process of fault diagnosis in gas turbines. Such a system would be based in the development and use of a Bayesian network which could represent the probabilistic relationships between gas turbine faults, their symptoms and root causes.

The researcher engaged in the development of a Bayesian network that described the most frequent fault in GTM products, along with the probabilities associated to different symptoms as understood by Help Desk engineers. Also involved in such a process were engineers from the design, development and manufacturing departments at GTM Ltd.

A series of collaborative modelling exercises took place between April and October 2007. As a result of these meetings a fault diagnosis system was developed. However, as reported by the author in a previous publication, the collaboration with GTM Ltd was also perceived by the organisation as a successful approach to eliciting knowledge from Help Desk experts and transferring such knowledge to engineers from other departments. It was later found that the project had a number of additional, unexpected outcomes that included the emergence of new communities of professional interest within GTM Ltd, the value of the Bayesian network for the training of customers and GTM personnel working in the field, and an increased awareness, at a management level, of the need to share the knowledge of GTM experts on a regular basis.

A review of the literature was then conducted in an attempt to identify other work that was relevant for the formalisation of the strategy adopted. The literature review, included in this dissertation as chapter II, explored the potential advantages of combining facilitated group meetings with the use of models and modelling for the purpose of overcoming the known limitations of current approaches to KET in organisations.

4.1.2. The fundamentals of the new approach to KET

The collaboration with GTM Ltd led to the formalisation, validation and refinement of a people-based approach to KET based on facilitated, collaborative modelling of domain knowledge. This new mechanism is characterised by three major issues. These are:

- Its people-based perspective, with no dependence on the use of information and communication technologies.

- The use of a facilitator or moderator for the KET process.
- The use of models and modelling as an aid to the KET process.

The remainder of this chapter will provide details of the new approach and outline how the GTM Ltd experience informed its development.

4.2. CoMEx: A method for the implementation of the new approach to knowledge elicitation and transfer

4.2.1. Introduction

In order to help organisations understand how this new approach to KET can be applied in practice, this research has designed a method that defines a set of steps that organisations can run. The method follows the guidelines outlined in section 4.1.2 by running the following steps:

1. Identifying key **concepts** within the knowledge domain.

The field work starting at GTM Ltd suggested that the process of identifying key concepts helps individuals to structure their understanding of the domain. Later, relations between concepts become the basis of the analysis leading to the acquisition of new knowledge.

2. Using those concepts as a starting point for the collaborative development of one or more **models** of domain knowledge.

The ease of communicating knowledge is almost completely determined by the way the knowledge is conceptualised and represented. A well-chosen analogy, anecdote or diagram can make all the difference when trying to communicate a difficult idea to someone, especially someone who understands but is not an expert in the field (Shadbolt and Milton, 1999, p. 311).

3. Analysing the connections between these models and the **experience** of individuals involved in the KET exercise.

The field work suggests that this analysis motivates a debate where knowledge flows between individual participants and new ideas emerge as a result of preconceptions being challenged and feedback being provided.

The method has been called CoMEx to capitalise on the importance of its key components: Concepts, Modelling and Experience.

Some key roles that the implementation of CoMEx involves are:

1. The KET facilitators.

The role of a facilitator is one of influencing the group dynamics when necessary in order to encourage participation and ensure that the process keeps focused on relevant knowledge.

Individuals in this role will need to have specific skills in facilitation of group meetings. These skills include personal attributes such as being genuinely interested in hearing other people's thoughts, being animated and spontaneous, admit their own biases and express thoughts clearly (Stewart and Shamdasani, 1990, p.79). Necessary skills will also include the ability to conduct a successful group session, from beginning the session to assuring participation, managing time, probing, and dealing with problems such as the presence of a hostile group member (Stewart and Shamdasani, 1990, p.87-101).

One or more KET facilitators can be involved in an application of CoMEx, either simultaneously or at different stages. Krueger and Casey (2008, p.192) suggest that for group meetings two facilitators (one being an expert in conducting the meeting and the other one being an expert in the topic of the discussion) may achieve better results than one. Particularly relevant in this respect is the experience gained in fields such as training and development or facilitation of group dynamics. Research in these areas has considered the importance of a facilitator's leadership style, approaches to questioning, their characteristics and behaviours (Krueger and Casey, 2008). Stewart and Shamdasani (1990) also recommend considering facilitators' training and preparation to deal with situational variables such as disruptive groups or resource constraints.

2. Individual participants. These will be domain experts or individuals who can potentially benefit from acquiring or applying their knowledge (referred to as stakeholders).

The KET experience at GTM Ltd was based on the organisation selecting the individuals that would take part in the meetings. The selection was made on the basis of managers' perception of knowledge needs in their teams and the ability of certain individuals to contribute to filling the knowledge gaps of others. Although this approach to selection of participants avoids the analysis of what expertise is and what defines an expert, it was adopted with success in all subsequent KET projects implemented in the field.

Although there was agreement between the researcher and GTM Ltd management about the KET rationale of their collaboration, the purpose of the project as presented to participants was the development of a model for the implementation of a fault diagnosis system. The potential benefit of having such a system was the key motivating factor for experts to contribute their knowledge. Thus, the researcher followed the manager's advice and did not reveal the main aim of the project to participants. The success of adopting this approach led the researcher to avoid presenting CoMEx as a KET method to individual participants in all subsequent exercises. While this approach remained valid, there is a question to be studied in relation to how participants react if they are aware of the main outcome expected from the implementation of the method.

CoMEx has been used throughout the implementation and validation stages of this research. However, it is important to mention that this method does not represent the only mechanism by which the new approach to KET proposed can be implemented. The flexibility of this new approach enables the KET facilitators to adapt its implementation to the context and the circumstances in which it is to be applied.

4.2.2. CoMEx: The method

Conducting a KET project based on collaborative modelling of domain knowledge as defined by CoMEx comprises four key phases. These are:

1. Project initiation. The organisation and KET facilitator(s) agree on the feasibility of implementing the method, its expected outcomes and the mechanics of its application. Formation of the KET team is a key outcome of this stage.

2. Project preparation. The facilitator(s) extract key concepts about the knowledge domain and represent the relations between such concepts in one or more initial models.
3. Knowledge elicitation and transfer meetings. The KET team collaboratively develops models of the knowledge domain and analyses how the models developed relate to their personal experience.
4. Post-process review. The facilitator(s) lead individual participants to reflect on their learning experience.

The relation between these four stages is represented in figure 4.1 below.

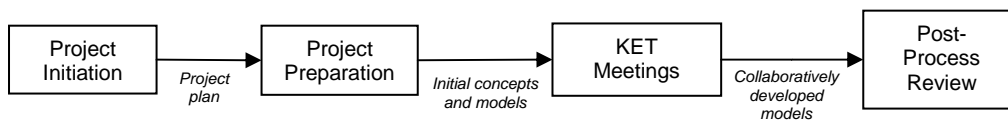


Figure 4.1. Key stages of the implementation of CoMEX

The remainder of this section will outline the rationale and strategy for the implementation of each of the four CoMEX stages. These are based on the theoretical issues underpinning the method and the experience gained by applying and refining it in the field, which will be discussed in chapters V and VI.

Stage 1. Project initiation

A KET project has a significant cost for an organisation. If nothing else, there is a cost involved in releasing a number of key individuals from the production line in order to participate in the KET meetings. However, the starting point for a KET project is the assumption that the organisation is aware of its benefits and determined to commit the required resources to its implementation. Therefore, the aims of the project initiation stage are:

- Establish a mutual understanding between the organisation and KET facilitator(s) about the need for and the expected outcomes of the KET process, and

- Set the grounds for the implementation of CoMEx.

In order to achieve such aims the KET facilitator(s) and the project sponsors are expected to discuss and agree on the following issues:

1. The knowledge domain to be analysed.
2. The project participants.
3. The arrangements for the implementation of the KET project.

The knowledge domain to be analysed

CoMEx relies on the ability of the project sponsors to identify pockets of expertise which could usefully be shared among individuals and workgroups. It is important that this knowledge is specified as precisely as possible by the organisation and that clear objectives are set that provide a boundary to the project. In the GTM exercise, for example, the organisation was aware of its need to share knowledge about the operation of gas turbines, and the process was kept within the boundaries of such knowledge. The same approach was followed with success in other environments, covering areas such as the characteristics of a research project, the process of dealing with customer queries in a major engineering project, or the delivery and maintenance of a specific infrastructure.

The project participants

Project participants are selected by the organisations involved in the implementation of CoMEx on consideration of the knowledge domain to be analysed. Although this is considered to be a valid approach, there is awareness of the importance of also taking into account additional factors when selecting the participants. This is particularly important in the view of Stewart and Shamdasani (1990, p.36), who argue that success of a KET project can be maximised by appropriate selection of participants.

There are individuals whose intrapersonal characteristics may have a negative effect in the behaviour of other individuals involved and that of the group itself. Such characteristics are determined by physical, personality and demographic variables. It is therefore recommended that organisations use their discretion on the selection of participants by considering factors related to the individuals, such as their verbal skills and cognitive styles, i.e. their approach to solve problems within the relevant domain using the information available, and their ability to explicate and question the process.

Based on the experience of running CoMEx in the field, there are no particular restrictions on the background of individual participants. They may have similar, complementary or even contradictory views of the domain. Indeed differences in their perspective should help to expose differences in understanding of the domain. Such differences have the potential to encourage collaboration during later stages of CoMEx and ultimately foster learning.

Eight individuals were involved in the meetings at GTM Ltd. A relatively similar pattern was followed in other environments, with significant levels of success. The review of the literature on group techniques later corroborated that KET teams should include between 5 and 10 individuals for optimum results to be achieved.

Other relevant issues related to the selection of individual participants include those determined by the context where the KET exercise is held. These include, for example, organisational politics, intra-organisational cooperation and competition between individuals and groups and the effects of the organisational structure on the success of the KET process.

The arrangements for the implementation of the KET project

Finally, the technicalities of the implementation of CoMEx are discussed and a project plan is agreed. It is recommended that the plan covers the implementation of all subsequent stages of CoMEx, with particular emphasis on the collaborative modelling meetings. As a project in itself, the KET exercise will benefit from the analysis, at this stage, of project management issues such as risks and their mitigation strategy, how to communicate with the different stakeholders, etc. It is important for sufficient time to be allocated to the project and each of its stages, which will entail the participants interacting with the facilitators and attending a series of meetings that may extend over a period of weeks.

On completion of the project initiation stage, the KET facilitator(s) and the organisation will have agreed on an overall plan for the implementation of CoMEx. If necessary, a confidentiality agreement will have been signed by the facilitator(s).

Stage 2. Project preparation

The GTM experience suggested that, in order to be more effective, facilitators are expected to gain a basic understanding of the key concepts defining the knowledge domain before the KET team meets. Application of CoMEx at GTM Ltd and other organisations showed that such an appreciation of the nature of the domain knowledge by facilitators can be gained from at least two main sources:

1. The view from individual participants in the KET project.
2. The documentation made available to the facilitators by the organisation.

Capturing individuals' understanding of the knowledge domain

Semi-structured interviews on a one-to-one basis will seek to capture individuals' understanding of the domain and issues that are relevant to them and which need analysis. These interviews will produce questions, or suggestions for key concepts that relate to the area of interest.

The facilitators may extract the main questions and concepts so that they can be fed back to the participants when they meet as a group. The concepts that are relevant will vary depending on the domain. For instance if the domain of interest was that of project management then relevant concepts might be identified as project phases, completion criteria, project categories, staff roles and so on. In another domain, such as that of GTM Ltd where the focus of the KET project was fault diagnosis in gas turbines, a completely different set of concepts, such as subsystem, gas turbine status, fault category were identified.

The questionnaire used for interviews during the preparation stage of a CoMEx application in the field included the following questions:

- What kind of work have you / do you carry out which relates to the domain?
- What experience do you have of the domain?
- What do you think are the key concepts or techniques which someone in the domain needs to be familiar with?
- Are you aware of the kinds of problems and issues which arise in the domain?

- What are the main activities in the domain? Do these activities have a natural sequence of phases (within them / between them)?

All questionnaires used in the field are included in appendix A, within the folder corresponding to each application of CoMEx in the field.

Document review

KET facilitators will need, within the constraints of any intellectual property or sensitivity of the information, access to documentation or background material relevant to the transfer exercise. Relevant concepts will be extracted while such documents are reviewed. The documentation might include sales literature, user manuals and so on. In the collaboration with GTM Ltd the facilitator was provided with documentation emerging from other projects related to gas turbines, a sample of the information generated by gas turbines when they failed, and commissioning and service reports produced by engineers in the field. The facilitator can understand the context from the document analysis and get a feel for the terms and vocabulary used.

The findings of the applications of CoMEx in the field suggest that access to in-depth or detailed documentation by the facilitators is not needed at this stage.

How are these concepts fed back to the KET team?

Once the facilitators have understood some of the key concepts that define the knowledge domain, they will seek appropriate ways of representing the relationships between such concepts. Such early representations will constitute the starting point for the discussions and analysis of the domain knowledge. Experience of running CoMEx in different contexts suggests that there are no restrictions in the representation schemes that can be used to such aims. These can be as complex as a Bayesian network used in the GTM case, as intuitive as a flow chart or as simple as a set of bullet points.

Different project participants may have a different perception of what the key concepts are or how these are organised. Although during the applications of CoMEx at GTM and other organisations all participants accepted the initial arrangement of concepts proposed by the facilitator, there is a risk that the facilitator may impose an invalid or incomplete representation of domain knowledge to the KET team.

One of the potential outcomes of having a limited representation of the domain could be a more intensive discussion and collaboration leading to successful knowledge elicitation and transfer. However, presenting an invalid picture of the domain may well have negative consequences for the purpose of knowledge elicitation and transfer. Facilitators are encouraged to produce a representation of the knowledge domain that is valid and captures the views of all participants.

Stage 3. The knowledge elicitation and transfer meetings

The KET meetings constitute the core of the KET experience for participants. This phase consists of a series of facilitated, face-to-face discussions where the main role of the team is to develop models of the knowledge domain and analyse how their individual experience relates to the models developed. The totality of these meetings is expected to be organised and managed by the KET facilitator(s), though the field experience suggests that support from project sponsors may occasionally encourage participation.

Each meeting starts with the facilitator outlining the current state of the project and a brief agenda to frame the modelling topic. The team then moves on to a facilitated model development or analysis session, depending on the purpose of each specific meeting. In each meeting the KET team works using concepts identified and models developed in previous sessions or during the CoMEx preparation stage.

Three types of meetings may take place during this stage. These are:

1. Meetings that focus solely on collaborative modelling of domain knowledge.
2. Meetings where the models developed are analysed against the experience of participants.
3. Meetings that combine modelling with analysis of participants' experience.

The experience suggests that the number of meetings of each type to be held varies depending on the complexity of the knowledge domain. Transfer of knowledge about operation of gas turbines at GTM Ltd required more than three meetings where modelling was combined with the analysis of individuals' experience. In other domains, however, one to two meetings have been enough, provided that each lasted

approximately one hour and had a clear purpose, i.e. either modelling or experience analysis. Based on the field experience it can be argued that meetings are more effective when they last between 60 and 90 minutes. Ideally, they will occur at regular intervals and provide individuals with significant time for reflection between meetings.

Environmental variables play a key role in the success of these meetings. Special attention should be given to concepts such as territoriality, spatial arrangements and interpersonal distance. In that respect, it is recommended to follow the relevant lessons learned from the fields related to group dynamics. These concepts are related to the assumption of a proprietary orientation toward a geographical area by an individual, and the personal norms that are established about the appropriate or preferred distance between themselves and others. According to Shaw (1981), these issues have highly significant implications for small group behaviour, as the smooth functioning of the group often depends upon the degree to which group members respect each other's assumed territorial right.

1. Collaborative modelling meetings

During these meetings the KET team is expected to develop models of specific areas of the knowledge domain. Using techniques for facilitation of group dynamics the team will be encouraged to discuss whether the concepts are viewed in the same way by all participants and whether any concepts or questions should be modified and how. Facilitators will seek to encourage the team to contribute their knowledge and try to understand the knowledge of others while a model is being developed on the basis of the discussion. The field experience has shown that the most intense elicitation and transfer of knowledge takes place during the period in which models are being developed.

The GTM experience suggests that a Bayesian network was successful in supporting collaborative team work as part of the exercise. The Bayesian network also was, in this case, a suitable model for the implementation of a fault diagnosis system, ultimate aim of the exercise. Different, less structured representation schemes were used in other contexts with similar levels of success. In all cases, the representation schemes were chosen by the researcher based on previous knowledge representation experiences. Experience in the field showed that, when presented to the corresponding KET teams,

reactions to initial models ranged from complete acceptance to total rejection. They were either left unchanged, modified, or re-created using a different perspective. However, in all cases the models presented motivated a discussion leading to the elicitation and transfer of knowledge. On this basis it can be argued that there is no known restriction on the characteristics of the models to be developed or the knowledge representation scheme to be used.

The experience of applying CoMEx in the field suggests that these meetings achieve best results when participants sit in a U layout as represented in figure 4.2 below. The distribution of experts and stakeholders across the U layout has been determined in all cases by the individuals' own choice.

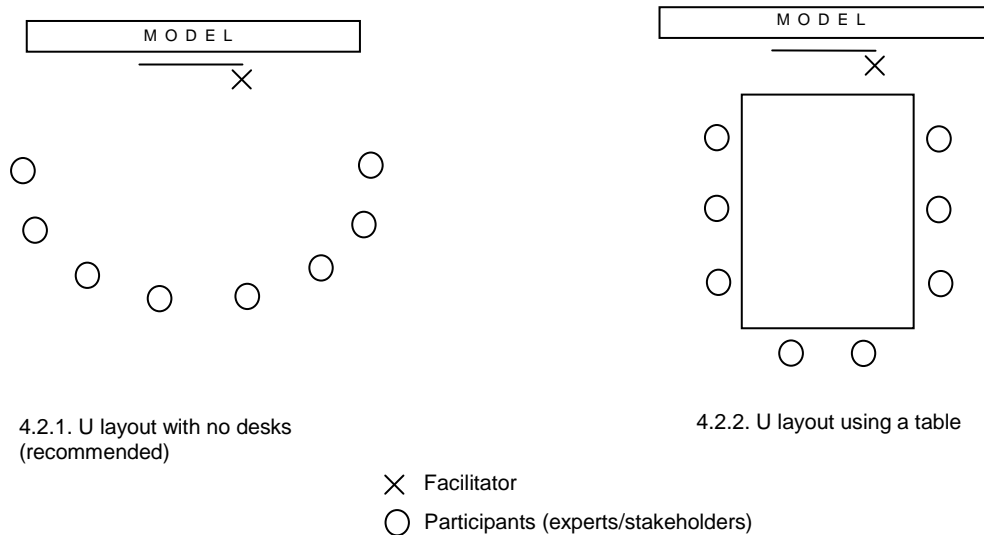


Figure 4.2. Variants in the room layout for the collaborative modelling session

According to the field experience, the first meeting of the KET team is expected to involve a significant degree of modelling. To such an aim, the facilitators will use the results from the preparation stage to provide an initial set of concepts and questions to be discussed. The concepts and their relationships will be represented using a scheme derived from the background preparation carried out, as described earlier in this section.

As the discussion progresses, the KET facilitators capture the main ideas using the chosen representation scheme in a space that is visible to all participants, on a board,

flip chart or a similar tool. The field experience suggests that the use of colour codes during the development of the model helps its understanding.

According to the lessons learned from applying CoMEx in the field, a room with no desks will discourage note-taking and support participation in a discussion around the models being developed. There are no other specific requirements regarding spatial arrangements or room components such as availability or position of furniture, or the location of windows and doors. The experience suggests that breaks for refreshments or lunch when appropriate do not have a negative effect in the outcomes of the exercise.

A brief review is carried out when a model has been completed or when the time indicates the need to close the discussion. Participants are expected to decide whether they have yet achieved the objectives originally set for the transfer project or additional meetings are required. The KET facilitators play a key role during this review, as they are informed of the expectations that the organisation has from the KET exercise.

2. Experience analysis meetings

The aim of these meetings consists on using the models already produced as a mechanism to motivate self reflection leading the group, and particularly the experts, to provide feedback on each individual's experience. The principle driving this aim was outlined by Ford and Bradshaw (1993, p. 1) as follows:

“Modelling is purposive, that is, to be involved in modelling is necessarily to be engaged in using the model”.

These meetings therefore focus on using the models already produced by the KET team during the CoMEx exercise with the aim of supporting their learning experience. Questioning techniques and other facilitation strategies that seek to encourage participation become particularly relevant.

After the team has analysed the current state of the project and set the agenda for the meeting, the models already developed are presented to participants. This is followed by a discussion of the models' relation to individuals' experience. The experience of running CoMEx in the field suggests that a significant degree of feedback is provided by the team to each individual while the areas of stress of their work are analysed.

Equally relevant during these meetings are the environmental variables previously discussed. The experience of applying CoMEx in the field suggests that best results are achieved when participants sit in a circle layout or around a table as represented in figure 4.3. This is because interaction between participants and the role of experts become more important in this kind of meetings.

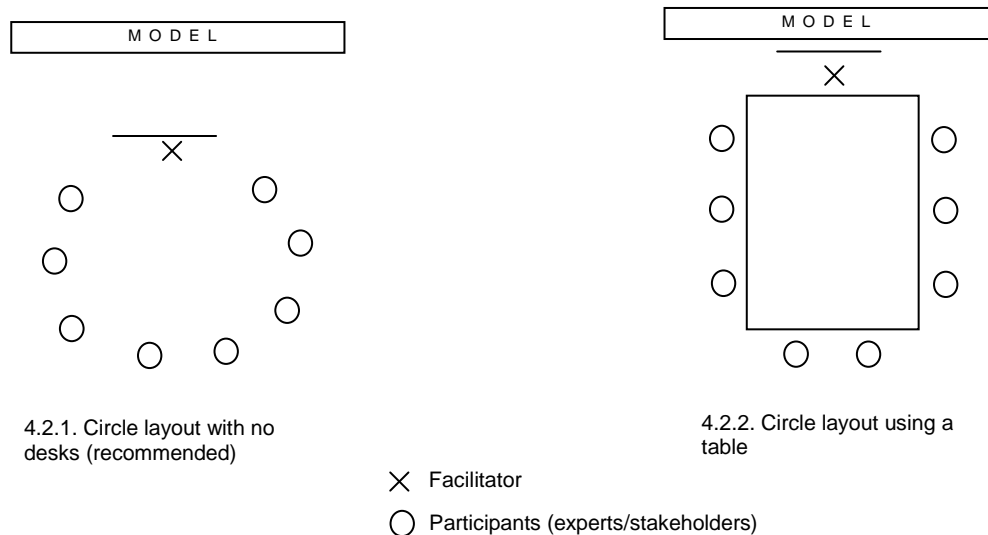


Figure 4.3. Variants in the room layout for the experience analysis session

Similar to other meetings previously discussed, the lessons learned from applying CoMEx in the field suggest that a room with no desks will encourage participation in the discussion. No other requirements regarding spatial arrangements have emerged from the field work.

A meeting is concluded when all participants have provided their views on the validity of the models developed and its relationship with their personal experience. This analysis must also be tailored to fit the time available for the meeting. However, a brief review of the meeting and the project is carried out at the end in order to decide whether further meetings are necessary.

3. Modelling/Analysis meetings

Based on the experience of running CoMEx in the field, there is a possibility of holding meetings where model development is combined with analysis of participants' experience. This has taken place in more than one application of CoMEx due to a variety of reasons, without this affecting the perceived quality of the KET process.

These meetings are introduced as a session that will focus on collaborative modelling, with the corresponding spatial arrangements. When the modelling session is exhausted the facilitator starts a discussion of the relation between the models developed and individuals' experience. The meeting and its arrangements may then change its perspective to enable communication and discussion between participants. For instance, the room layout can change from one of those shown in figure 4.2 to one in figure 4.3, without causing a major disruption in the flow of the meeting. The role of the facilitator is also affected by this change. Finally, the meeting concludes when all participants have provided their views on the relationship between the models produced and their personal experience.

Other issues related to the knowledge elicitation and transfer meetings

It is important that the number and identity of participants remains consistent throughout all the KET meetings. The experience at GTM Ltd and other organisations suggests that individuals find it easier to describe the relation between a model and their experience if they participated in the session where the model was developed. Similarly, the learning experience is incomplete if either experts or stakeholders are not able to reflect on the value of the models with the members of the group that participated in their development.

After each meeting the facilitators will document the current set of concepts and their representation in order for these to be circulated before the next meeting. This record will then provide the starting point for the introduction of the next KET meeting.

It is possible that new questions and issues that are relevant but fall outside the focus of the KET transfer will arise in the course of the meetings. These may lead to further KET exercises being carried out. It is preferable to keep each CoMEx implementation focused on its initial objectives since it may become appropriate to include different individuals should the objectives be modified.

The use of technologies is significantly low during the running of the meetings. However, the GTM experience showed that technologies can be used in particular to support the planning of the meetings.

With the exception of the KET facilitator(s), preparation of the KET meetings is not expected to demand a significant amount of resources, i.e. time and effort, from individual participants.

The models, as an explicit representation of the knowledge domain, developed by the KTE team are the only formal documentation expected to result from the KET meetings.

Stage 4. Post-process review

The last stage of the application of CoMEx is a review of the topics discussed during the previous stages of the KET exercise and in particular during the KET meetings. The review involves the KET facilitators and participants on an individual basis. This review focuses on encouraging knowledge acquisition through self-reflection.

The post-process review is an attempt to enable each individual participant to revisit the issues already analysed, now in an environment that is free from the influence of others. It is based on the concept of the After Action Review process, which according to Morrison and Meliza (1999) was initially developed by the US Army for providing performance feedback from a collective training exercise. CoMEx, however, seeks to support participants in analysing what was concluded and the reasons behind it.

The post-process review takes the form of one-to-one, semi-structured interviews that take place some time after the last of the KET meetings. Although facilitators are free to ask questions that are specific to the particular project or domain, it is recommended that those questions cover at least the following issues in order to achieve the aims of this stage:

1. Relation between the models and concepts as documented and what was agreed in the meetings.
2. Areas where the models or concepts could be changed.
3. Perceived changes in their conception of the knowledge domain.

4. Ways in which the concepts and model could be used.

There are additional outcomes of the post-process review stage. The GTM experience suggests that individuals' analysis of changes in their own perception of the domain leads to an assessment of the value of the KET for the organisation. The post-process review is likely to raise awareness in individuals and their managers of the importance of knowledge sharing. It has been a pattern that organisations at this stage explore the potential need for other KET exercises, with suggestions of relevant areas to be covered in the future.

Conclusion

Specific aspects of CoMEx still require analysis and development. However, the method is being presented with the stability provided by its application in different environments. The main issues characterising the method can be graphically represented as in figure 4.4.

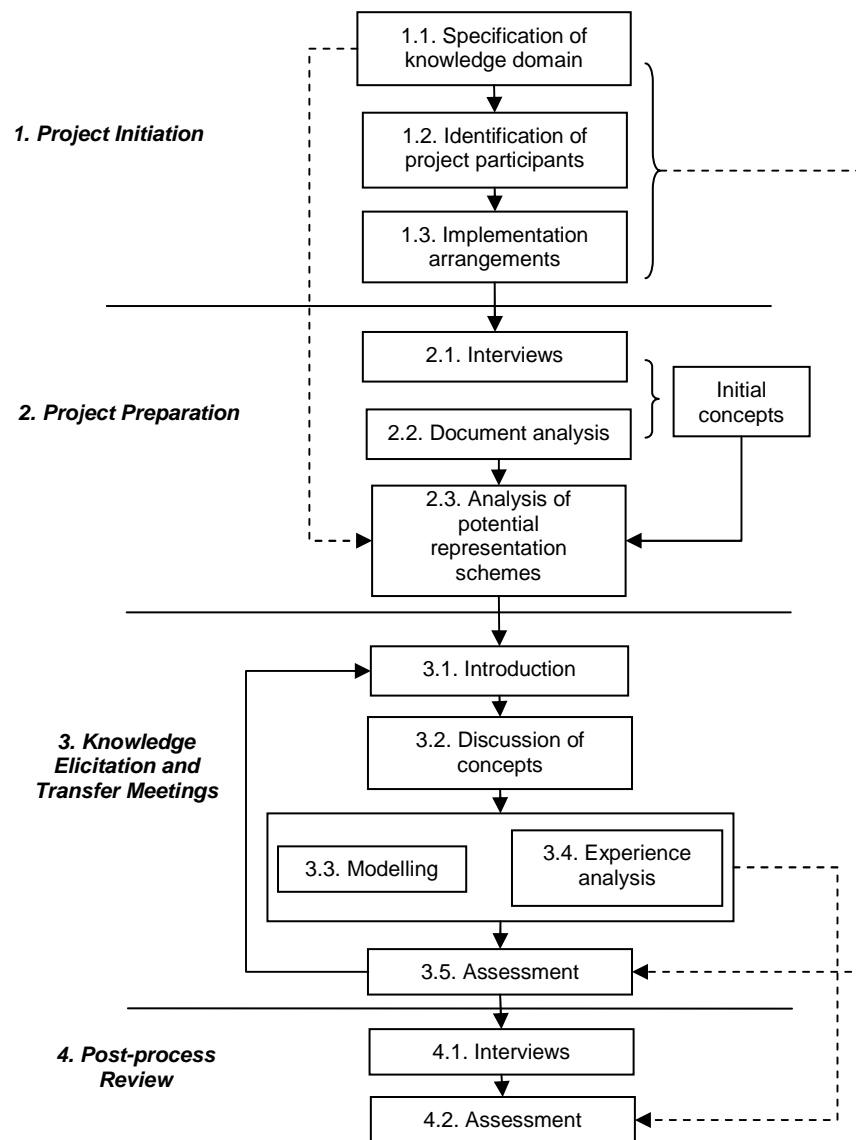


Figure 4.4. Relationship between the key stages of the implementation of CoMEX

4.3. Implementing a knowledge elicitation and transfer exercise using CoMEx

4.3.1. Introduction

The version of CoMEx presented in section 4.3 is the result of the evolution of the method that originated at GTM Ltd, based on its application in different contexts over a period of three years. A total of nine CoMEx exercises in four different organisations followed the collaboration with GTM Ltd. These were, chronologically:

- 3 applications in a research organisation.
- 5 applications in an engineering organisation.
- 1 application in a programme management organisation doing defence-related work within the UK Ministry of Defence.

It is the last one of this series of KET exercises which has been chosen to illustrate how CoMEx can be run in an organisation. It must be said that although CoMEx had evolved significantly when this application took place, the process described in this section still has particularities that were not encountered in previous KET exercises. This shows that CoMEx is still an evolving method and further applications are needed for all relevant issues to be fully understood.

A programme management section was created within the Ministry of Defence (MoD) with the aim of delivering the infrastructure required by personnel in the battlefield. The priority for the newly created section would be the management of a large budget with the aim to develop and deliver the infrastructure required for the accommodation, medical and welfare facilities of UK and NATO personnel in a remote location. An intense collaboration between the MoD section and a broad range of institutions was foreseen, and therefore eight experts from different backgrounds were recruited. This multi-disciplinary team would need to define and implement the long-term strategy for the infrastructure delivery programme. The section will be referred to as MoDInfra in the context of this thesis.

Due to the nature of the work of MoDInfra, individual members of the team would be working from remote locations in the UK at least for an initial period of time from their recruitment. Although each of these individuals had significant experience in their specific domains, only some of them had worked on similar projects in the past. In a way, each of the individual members of the team was the expert in his or her domain, and that expertise had to be shared in order for the team to have a common view of MoDInfra, its aims and the scope of its work.

This lack of a clear distinction between the set of experts and stakeholders was a situation that had not been found in previous applications of CoMEx. However, the evaluation of the exercise suggested that such situation was never a barrier to the elicitation and transfer of knowledge.

The researcher and MoDInfra established a collaboration that ran between December 2008 and November 2009. The aim of the project was to elicit relevant knowledge from each of the newly recruited staff at MoDInfra and transfer that knowledge to the other team members.

An application of CoMEx marked the beginning of the design and implementation of the MoDInfra programme. The key dates and events that the KET exercise involved are included in table 4.1.

Table 4.1. Implementation of CoMEx at MoDInfra – Key dates and events

Date	Event
Stage 1. Project initiation	
2 December 2008	Introductory discussion
19 January 2009	Background information analysis
28 July 2009	Kick-off meeting
Stage 2. Project preparation	
July 2009 to September 2009	Document review and facilitator's interaction with participants
Stage 3. Knowledge elicitation and transfer meetings	
14-15 September 2009	First KET meeting
21 September 2009	Facilitator provides the KET team with the models developed
4 October 2009	Detailed preparation of the second knowledge elicitation and transfer meeting
5 October 2009	Second knowledge elicitation and transfer meeting
Stage 4. Post-process review	
13 October 2009 to November 2009	Interaction between facilitator and individual team members

In order to provide the reader with an understanding of how CoMEx can be implemented, the MoDInfra project will be described in this section using a chronological format.

4.3.2. Stage 1 – Project initiation

2 December 2008: Introductory discussion

After initial contacts a telephone conference was held including the PhD supervisor on the Cranfield University side and the future leader of MoDInfra.

The suitability of the collaboration was discussed in general terms. The discussion was focused on:

- A description of the knowledge problem at MoDInfra: the need for a common understanding of the expertise, aims and challenges of the newly created multi-disciplinary team.
- A discussion of the solution proposed by Cranfield University: a formal process for the elicitation of knowledge from individual members of the team and the acquisition of such knowledge by the rest of the team.
- The feasibility of applying CoMEx in the context of MoDInfra: confidentiality of the information, restrictions on access to MoD information by project participants, practicalities of the implementation.

Recruitment of individual members of the team was in process. Therefore, no date was set for the start of the KET project. The telephone conference motivated both parties to further discuss the problem to be solved by MoDInfra and the solution proposed by Cranfield University in more detail. To such aims a date was agreed for a face-to-face meeting.

19 January 2009: Background information analysis

A meeting took place at the location where MoDInfra would be based. The meeting included representatives of both parties involved, namely Cranfield University and MoDInfra.

A detailed introduction to the topic of defence infrastructure development and delivery was provided by the MoDInfra section leader. The role of the new section and its potential challenges were also outlined.

This was followed by a presentation by the Cranfield University representatives, which aimed at describing CoMEx as the approach proposed as well as the outcomes of its previous implementations in other contexts.

There was agreement on the suitability of a knowledge elicitation and transfer project involving the researcher as a KET facilitator. Although recruitment of MoDInfra team members was still underway, an early notion of the number of participants and their backgrounds was available. Also, location and other practical issues related to the execution of the project were discussed in this meeting.

28 July 2009: Kick-off meeting

Once the recruitment process had been completed a preparatory meeting was held at the location where MoDInfra would be based. The meeting was attended by the researcher and three members of the MoDInfra staff with different responsibilities that included, respectively, section leader, project manager and chief of staff. These three roles were key for the achievement of the aim and objectives of the new MoD section.

A detailed presentation of CoMEx was provided by the researcher, followed by a discussion of its theoretical and practical aspects, trying to uncover the potential benefits for the particular situation of MoDInfra. Attendants agreed that the following issues were expected to be key outcomes of the KET project:

- A vision of the aims and objectives of the section, and an outline of the projects and actions to be carried out in the first 10 months of its work.
- A clear understanding at a group level of each individual's background knowledge and their potential contributions to the aims and objectives of MoDInfra.

The project and its requirements were discussed and a detailed plan was outlined. Given the breadth of the body of knowledge to be elicited, the project would include at least one session of two full days for KET meetings. In an attempt to maximise their success, such sessions would be held at an MoD location with training facilities, where all participants could remain away from office and home environments. A prospective date for the meeting was set to September 2009 so that there was enough time to complete the project preparation.

Given that project participants were still located remotely, the researcher was provided with their profiles and contact details. Eight individuals would be attending the meeting, each of them in one of the following capacities:

- Section Leader: Delivery of MoDInfra aims and objectives
- Chief of Staff: Coordination and drawing together of all the strands within the MoDInfra team.

- Project Manager: Definition and management of all the projects to be delivered by MoDInfra. This includes providing the business cases, communication plans and projects governance.
- Programme Manager: Managing the programme and dependencies to support MoDInfra in delivering its outcomes.
- Industry Liaison Officer: Identifying appropriate commercial arrangements and liaison with industry.
- Knowledge Manager: Making the right information available to stakeholders as and when needed.
- Technology Manager: Ensuring that the technology required to deliver the programme is in place.
- Operations Manager: Ensuring efficiency of MoDInfra business operations.

4.3.3. Stage 2 – Project preparation

During the two months that followed the kick-off meeting the KET facilitator and representatives of the MoDInfra team prepared the first collaborative modelling exercise. The section leader, chief of staff and project manager organised the logistics of the project. In the meantime, the KET facilitator continued to follow the CoMEX guidelines in a direct contact with the project team using e-mail.

Based on the input received from MoDInfra during the initiation stage the facilitator designed a questionnaire that included the following questions:

- What do you see as the ultimate aim of the MoDInfra section?
- What do you see as the specific objectives required for that aim to be achieved?
- How do you foresee the process of working towards achieving those objectives?
- What do you perceive as your role in that process?

The questionnaire was administered to all participants by e-mail. All participants but one provided their responses. Their feedback complemented the analysis of the information provided in the kick-off meeting, enabling the facilitator to better understand the knowledge domain.

The facilitator extracted from these sources a set of concepts that included the following:

- *Infrastructure*: A concept used by individuals to refer to accommodation, medical and welfare facilities.
- *Accommodation facilities*: A concept related by individuals to life support infrastructure.
- *Medical facilities*: Used by individuals to describe the infrastructure required to treat patients.
- *Welfare facilities*: Initially described by individuals in relation to the infrastructure required to meet physical and social needs.
- *Infrastructure development*: Upgrade of existing facilities or addition of new infrastructure.
- *Infrastructure delivery*: Transportation and assembly of newly developed infrastructure where it will be used.
- *Infrastructure support*: The work needed to keep existing infrastructure functional.
- *Infrastructure maintenance*: Used by some individuals to refer to the concept of infrastructure support.
- *Sustainability*: Used in reference to the ability of project stakeholders to continually support the infrastructure development process.
- *Expansion*: The growth of operations carried out by users of the infrastructure.
- *Cost effectiveness*: Used by some individuals to refer to the balance between quality, time and financial cost of the infrastructure development process

The concepts identified were organised by the KET facilitator into three different categories as described by MoDInfra staff and the documentation made available.

These were:

5. MoDInfra context and aims:

- Deliver certain facilities to personnel with different roles in a mission within specific location and timescales.

6. MoDInfra objectives and milestones:

- Programme definition.
- Programme implementation.
- Delivery of solutions.

7. Individuals' roles and responsibilities:

This category covers, for every member of the MoDInfra team:

- Areas of expertise.
- Potential contributions to the critical factors leading to success of the programme.

In order to produce the initial set of models, a review of potentially useful knowledge representation schemes was conducted. The concepts within each category were organised by the facilitator into three models by following:

- The understanding gained by the facilitator from the review of relevant MoDInfra documentation.
- General principles about project management modelling described by authors such as Wideman (2004) and Forsberg et al. (2005).

Models such as the function-process-time relationship and multi-dimensional matrices including project life span, project elements and project management functions have been used to represent aspects of the project management domain.

- The ‘Strategic Linkage Model’ proposed by the Balanced Scorecard as a mechanism for visual documentation of links between measures. The scheme has been detailed by authors such as Kaplan and Norton (1996).

Versions of the models produced are included in figures 4.5 to 4.7. Potentially sensitive information has been omitted or altered in order to maintain the confidentiality of the organisation and its business.

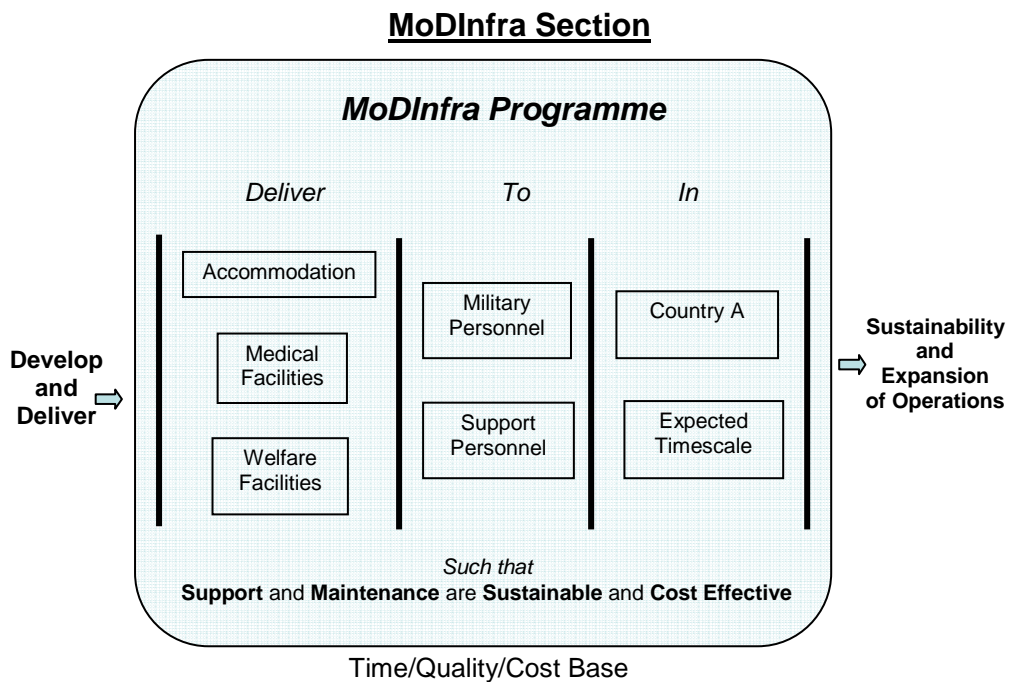


Figure 4.5. Initial models: MoDInfra context and aims

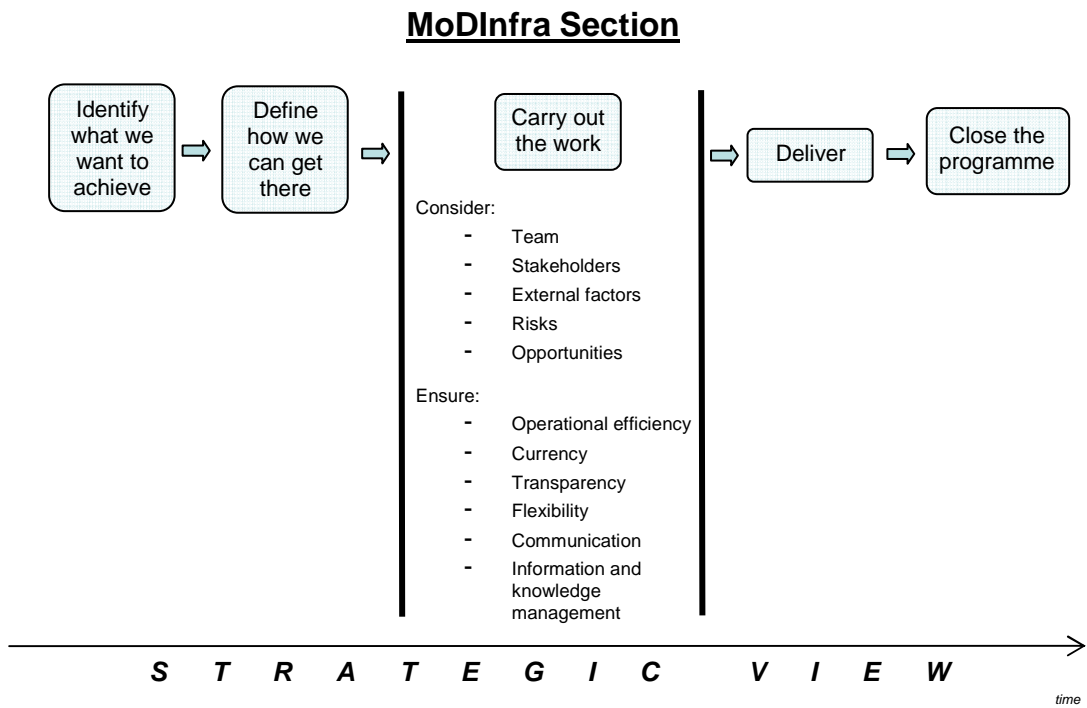


Figure 4.6. Initial models: MoDInfra objectives and milestones

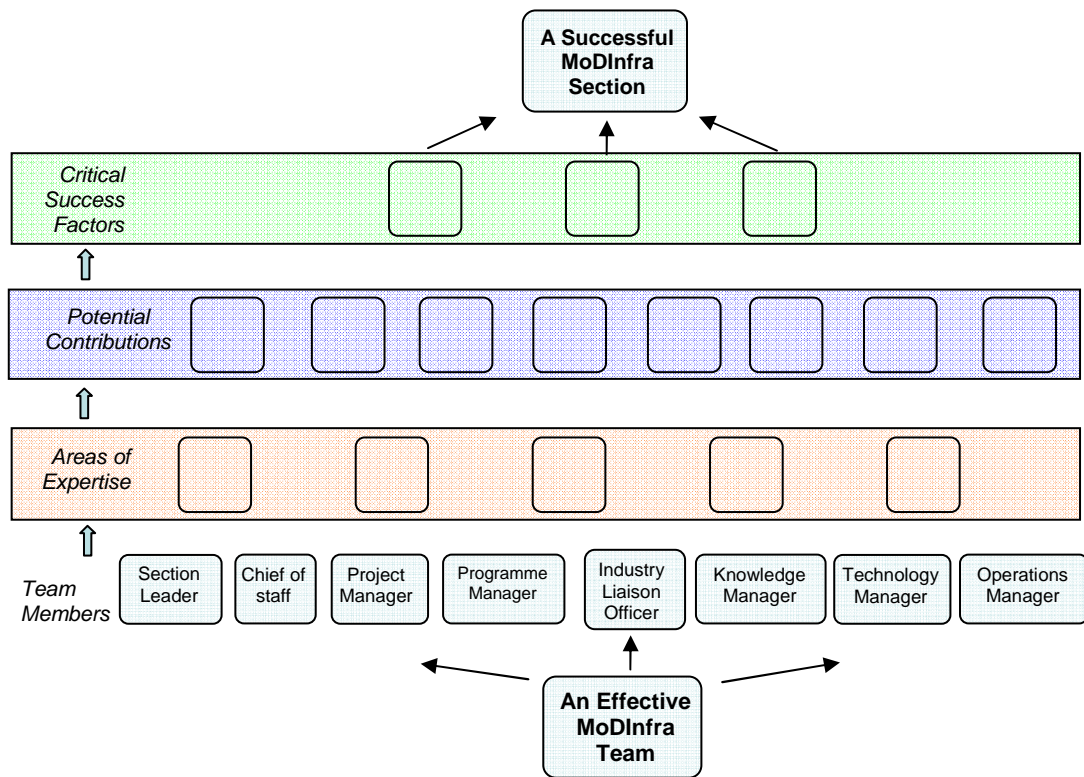


Figure 4.7. Initial models: MoDInfra section members' roles and responsibilities

4.3.4. Stage 3 – Knowledge elicitation and transfer meetings

14-15 September 2009: First knowledge elicitation and transfer meeting

The first series of meetings took place at the Defence Academy of the UK. On their arrival the team found that the room available did not have a whiteboard that could be used for the purposes of collaborative modelling. This issue was unique to this application of CoMEx and was resolved by doing the following:

- Displaying the initial models using a data projector connected to a computer in one side of the room.
- Forming a U layout where both the models and a flip chart were visible.
- Using flip chart sheets to develop the models and displaying these in the walls as they were produced.

The two photographs in figure 4.8, taken during a coffee break, show the room layout and the tools available from two different viewpoints. Figure 4.9 is a diagram showing the room layout.



Figure 4.8. The room layout during the first collaborative modelling meeting at MoDInfra

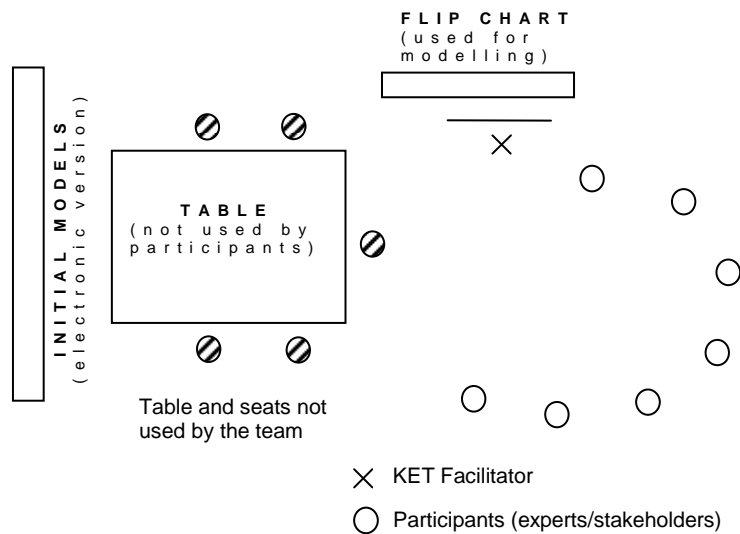


Figure 4.9. A diagrammatic representation of the room layout during the first collaborative modelling meeting

The meeting started with an introduction by the MoDInfra section leader. Instead of a KET project, the collaboration with Cranfield was presented as a team building exercise. The facilitator was introduced and the CoMEx session started.

The KET session started with the facilitator providing a general view of what would take place during the meetings, emphasising the three key areas that were expected to be covered: MoDInfra context and aims, objectives and milestones, and individuals' roles and responsibilities.

The facilitator presented the model in figure 4.5 as a result of the inputs received from the team, avoiding any reference to the contributions made by specific individuals. The inclusion of concepts such as *facilities* and *sustainability* in the model had an immediate effect in the discussion, raising a significant number of questions. This was the starting point of an intense discussion that lasted just over three hours, in which most concepts were carefully analysed and a completely new set of models was developed.

Figure 4.10 includes the result of the analysis of three concepts. These are: *Capability* (which resulted from the analysis of *Facility*), *Medical capability* and *Welfare capability*.



Figure 4.10. Results of the collaborative analysis of the concepts of Medical capability and Welfare capability

With different levels of participation, mainly due to the intrapersonal characteristics of individual participants, an extensive exchange of ideas and viewpoints took place. The role of the facilitator was limited to encouraging participation and keeping the discussion focused on the relevant topics. This was achieved by capturing in a graphical model the key issues raised.

During these two days the same process was repeated in an attempt to cover each of the initial models proposed by the KET facilitator (figures 4.5 to 4.7). Each session achieved similar levels of engagement by participants. The permanent display of newly developed models on walls using flip chart sheets became an advantage, as participants could revisit the evolution of their understanding of the knowledge domain, represented in more than 20 diagrams, during the two days of the exercise. The knowledge elicitation and transfer sessions alternated the collaborative modelling of the domain with the analysis of individuals' experience.

Having completed the development of the three models, the final hour of the second day was spent in trying to identify the key stakeholders of the MoDInfra programme. The team was able to identify more than 20 stakeholders and their levels of influence in the decisions to be made by the section. This was described by the team leader as one of

the key results demonstrating the common understanding achieved by the team with the application of CoMEx.

A review of the meeting was held by the team. Although a more formal evaluation is required and included in a later chapter, the feedback received at this stage suggested that most participants were satisfied with the results achieved by the team during the two days. It was agreed that a second KET session would be held by following a similar format with the aim of defining the specific projects to be carried out by the section over the following 10 months.

21 September 2009: Facilitator provides the KET team with the model developed

After the first set of knowledge elicitation and transfer meetings the facilitator framed the results into a single model, a version of which can be found in figure 4.11.

The MoDInfra Section

Models produced during the CoMEx workshop
Defence Academy, Shrivenham. September – October 2009

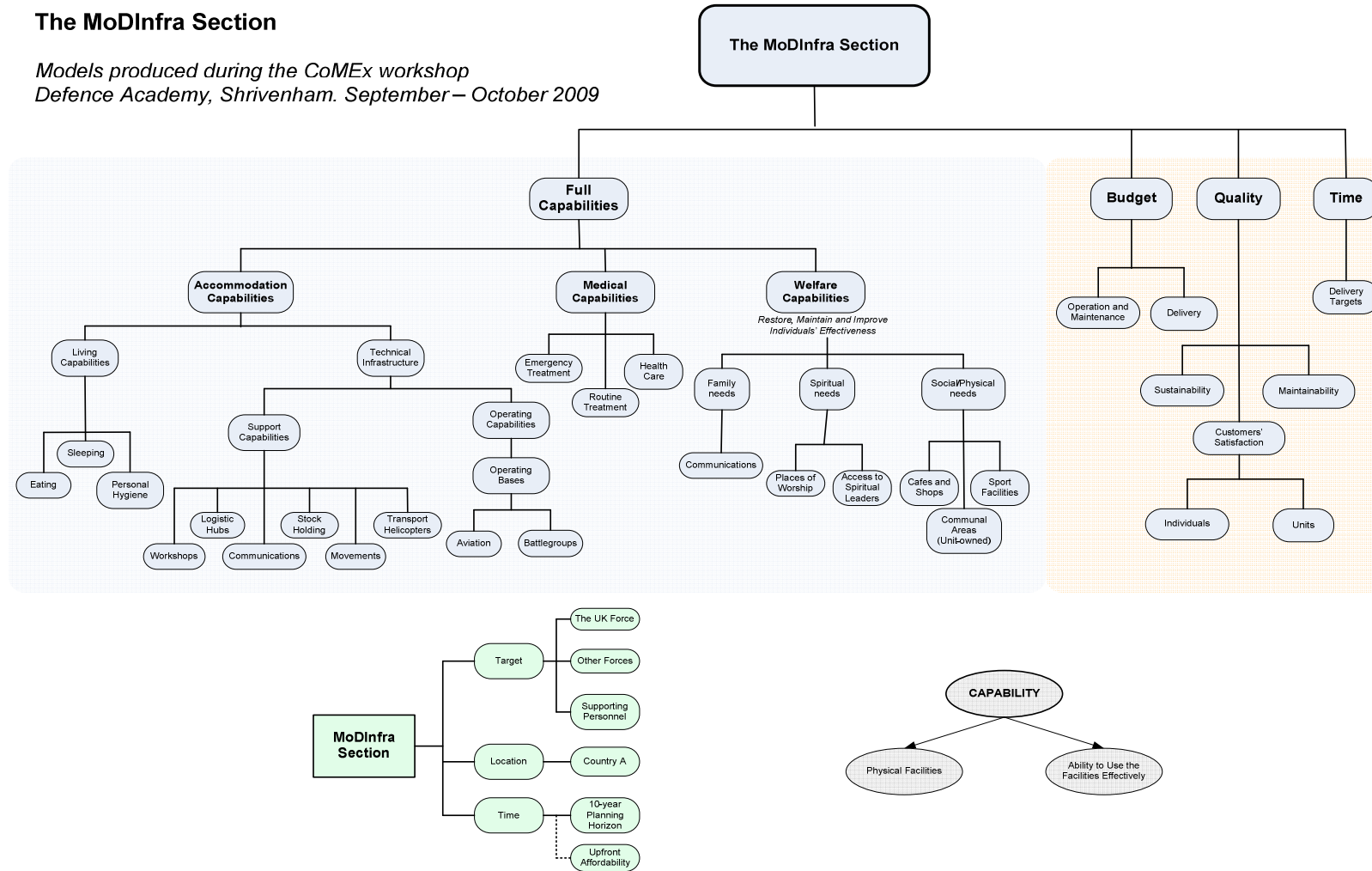


Figure 4.11. A version of one of the models produced as a result of the first knowledge elicitation and transfer session at MoDInfra

The models produced were e-mailed to participants on the 21 September 2009 in preparation of the second collaborative modelling meeting.

4 October 2009: Preparation of the second knowledge elicitation and transfer meeting

A telephone meeting was held between the KET facilitator and the MoDInfra section leader with the objective of defining the course of actions for the second set of collaborative modelling meetings.

Given the perceived success of the first modelling exercise, the MoDInfra section leader was interested in capitalising on the explicit outcomes of the KET project by developing a new set of key MoDInfra concepts through a similar modelling strategy. The resulting models would be used for the definition of the projects to be implemented by the team over the following 10 months, hence the importance of a shared view during the definition stage.

Working towards achievement of these aims would still encourage and facilitate the elicitation and sharing of knowledge, while also providing an opportunity to validate and further develop the KET method being used. Therefore, the facilitator and the MoDInfra section leader agreed on the variations of the format of the second KET meeting to ensure benefits for both parties involved.

5 October 2009: Second knowledge elicitation and transfer meeting

The MoDInfra team did not meet again until the 5 October 2009, when the second KET meeting took place in the same location. The meeting started with an introduction by the MoDInfra section leader. The expected outputs of this session and their importance were explained to participants.

The KET facilitator led a review of the model produced from the outcomes of the first KET meeting as a starting point of the discussion. The model in figure 4.11 was discussed, focusing on the ways the experience of each team member could contribute to achieving the objectives of the section. In this case such a relationship had already been achieved through a discussion of the connections between individuals' experience and the critical success factors for the MoDInfra section.

Key concepts that had emerged from the first KET meeting were extracted from the analysis. These included:

- *Technology*: In reference to all kinds of technologies that had to be considered in the infrastructure development process.
- *Communications*: How the infrastructure would allow different stakeholders to communicate.
- *Personnel*: Who would be involved in the use of the infrastructure and what their requirements were.
- *Ownership*: Who would own the infrastructure in the short, medium and long terms, and how the section would consider their requirements.
- *Flexibility*: Ability to meet the requirements of each stakeholder.

The KET team was split into smaller teams, each one including up to 3 members. Each team was then tasked with the development of a concept using a model of their choice. Every team spent approximately 30 minutes in developing the initial model. They then had the opportunity to review and modify the models produced by every other team, by adding new concepts and relationships between concepts. The KET facilitator worked in collaboration with the section leader during the first stage of the meeting in supporting individuals in the selection of representation schemes and the development of models. Figure 4.12 includes two of the models produced by the teams:

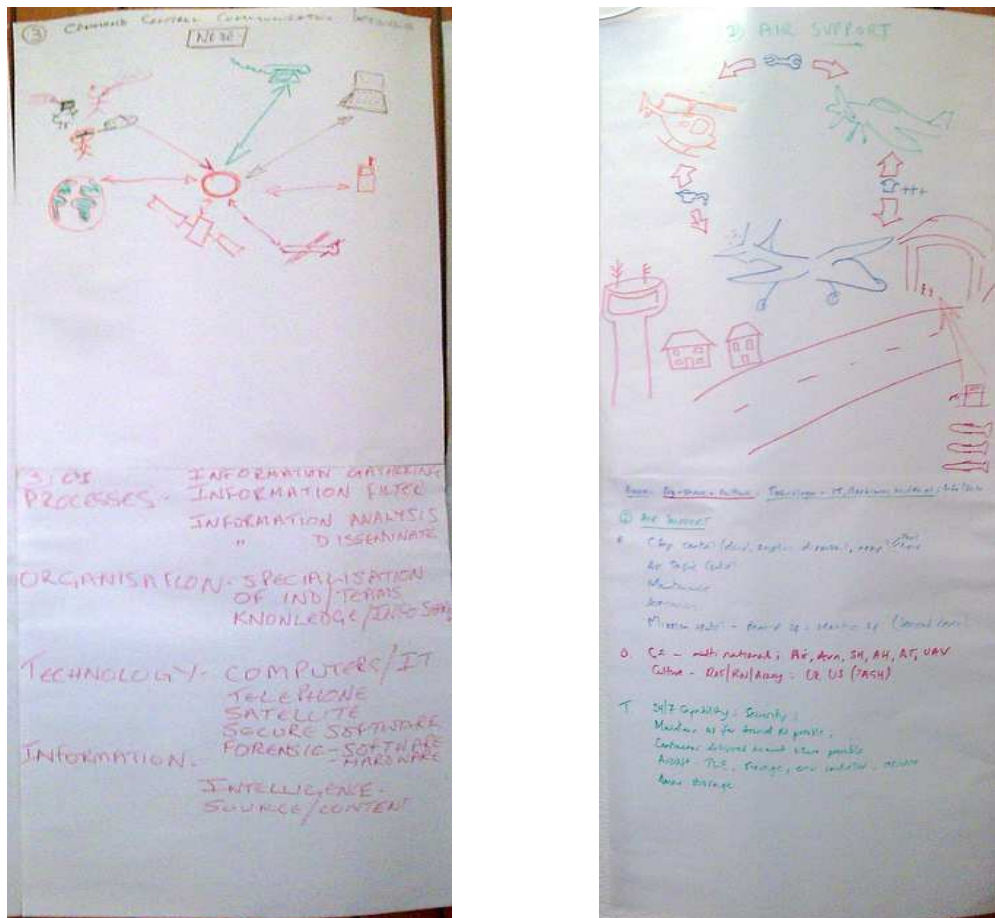


Figure 4.12. Two models developed by the MoDInfra team to describe, respectively, the concepts of Communications (left) and Air Support (right)

During the second half of the day the KET facilitators led a review of the models at a group level. Once these models were agreed by the team, the project manager would start using them in the documentation and analysis of each of the individual projects described. To such an aim the MoDInfra project manager agreed to complement the contents of flip chart material produced with the notes he took during the exercise and transfer the results to an electronic document, which would constitute the basis of the MoDInfra strategy.

By the end of the day an assessment of progress was conducted. The team had outlined its future work plan, identified key stakeholders and defined individuals' roles and responsibilities. No further KET meetings seemed to be required at this stage. There was agreement on the value of the exercise and the success of CoMEx, summarised in a

sentence by the MoDInfra section leader as “*the [MoDInfra] team exists, therefore CoMEx works*”.

4.3.5. Stage 4 – Post-process review

13 October 2009: Facilitator approaches individual team members

Following the second KET meeting, the facilitator produced an electronic document containing all models produced during the exercise. A week after the second KET meeting the facilitator approached each individual member of the MoDInfra section using the e-mail. The facilitator provided a copy of all models produced and a questionnaire that included the following questions:

- Do the models as documented and the concepts they include reflect what was agreed in the meetings?
- Do you see any scope for change in the models and the concepts included? If so, could you mention the areas where it could be changed?
- Has this exercise affected your conception of the MoDInfra programme and section? If so, could you briefly explain how?
- Are there any ways in which the resulting concepts and model could be used?
- Do the concepts and models developed tie in with your experience within this or other programmes?

All team members responded the questionnaire between October and November 2009. The level of the analysis in most responses received suggests that individuals took time to think about the main outcomes of the KET project. As a consequence, they were able to summarise the key changes in their perception of the aims and objectives of the MoDInfra section and the rationale behind their work. The post-process review had achieved its aim and the application of CoMEx, which is evaluated in chapter VI, was concluded.

4.4. Summary of key issues presented in this chapter

This chapter has presented the origins, foundations and ground rules of a new approach to KET in organisations based on facilitated collaborative modelling of domain-specific knowledge.

CoMEx has been presented as a mechanism for implementation of the proposed approach in organisations. CoMEx is based on the elicitation of concepts, the development of models and the analysis of relations between those models and individuals' experience.

An application of CoMEx in the field has been described. Its description may help organisations in the process of implementing this or a similar method.

The application of CoMEx at MoDInfra had specificities that may not apply to other contexts. For example, individuals were intrinsically motivated to share their knowledge with peers because they were all members of the same team, and knowledge sharing was a priority for the organisation. However, it has provided a view of the flexibility of the method to be adapted to the requirements of the organisation. It has also highlighted its ability to produce both implicit and explicit outcomes which may become particularly relevant for an organisation. CoMEx produced what was described by the MoDInfra section leader as "*a functional MoDInfra team*" within a period of weeks.

The following chapters will focus on the description and analysis of the applications of CoMEx in three different organisations, including MoDInfra, between 2007 and 2009. The data collected during the implementation of these exercises will be used to assess the validity of CoMEx as a method and facilitated collaborative modelling of domain knowledge as an approach to knowledge elicitation and transfer.

Chapter V

APPLICATIONS OF THE NEW APPROACH TO KNOWLEDGE ELICITATION AND TRANSFER IN THE FIELD

The key limitations that current approaches to knowledge elicitation and knowledge transfer face have been outlined in chapter II as a result of a review of the relevant literature. The principles of a new, people-based approach to knowledge elicitation and transfer in organisations were developed as part of a collaboration with an engineering organisation. The new approach and CoMEx, a method based on its principles, were formalised and presented in chapter IV.

This chapter describes how CoMEx was applied in three organisations between February 2007 and November 2009 with the aim of refining the method while also collecting data that would enable the assessment of its validity.

5.1. The principles of the data collection process

5.1.1. Research issues that lead the data collection

Once CoMEx had been developed, assessment of the method became the focus of the research. That is, the author would now focus on answering the main research question outlined in chapter I as:

How can the limitations of existing approaches to knowledge elicitation and transfer in organisations be overcome?

In doing this, the researcher would also seek to provide at least partial answers to the additional, more specific research questions also outlined in chapter I.

The conceptual framework presented in figure 5.1 below was derived from the analysis of the set of research questions leading this research.

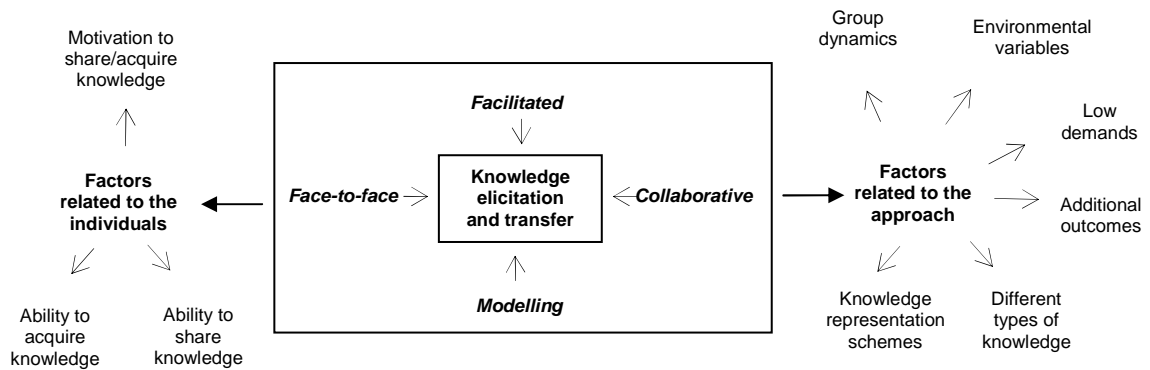


Figure 5.1. A conceptual framework designed for the study of the new approach to KET.

The conceptual framework was then used to extract the main issues that would lead the data collection process.

In order to address the main research question, the researcher sought to collect evidence from the field that could be used to assess whether the new approach to KET was able to overcome some of the main limitations of existing approaches. That is:

- The characteristics of the knowledge being elicited and transferred (e.g. its quality, ease of learning or applicability) do not hinder the success of the processes of transferring that knowledge from experts to stakeholders
- The demands of the new approach (e.g. time, skills and other resources) do not stop individuals from engaging in KET.
- The limitations in the process of selecting experts to be involved in KET could be overcome. The negative impact of issues such as their cognitive style or their spatial or verbal skills in the success of the KET process can be minimised.
- The new approach is successful in motivating experts to contribute their knowledge and also in motivating potential stakeholders to acquire and apply the knowledge of experts.

In addressing the additional research questions the researcher also sought to collect evidence from the field that shows that:

- The new approach considers at least some of the issues that influence individuals' comfort zones such as intrapersonal, interpersonal and environmental variables, in an attempt to maximise individuals' ability to openly communicate their knowledge.
- The facilitator of KET exercises becomes an enabler of the learning processes through an active control of the group dynamics.
- The new approach seeks to maximise knowledge sharing by encouraging an open communication of ideas where contributions are not restricted to specific group members, regardless of the level of their expertise.
- A process of collaborative development of models including experts and stakeholders increases the levels of knowledge sharing.
- The benefits of the new approach are not restricted to the elicitation and transfer of knowledge.
- The new approach facilitates the measurement of success of the KET exercise.

Finally, the collection of data was also influenced by the assumption that it would later be analysed by:

- Selecting sections of data that are relevant for the principles outlined above.
- Displaying such sections in a meaningful way.
- Using these displays to draw conclusions on the validity of the new approach to KET.

A further analysis and implementation of the evaluation strategy is carried out in chapter VI.

5.1.2. How the data has been collected

Refinement and assessment of the validity of a new approach to KET requires direct experience from the field. This means that the specific data collection and analysis strategies in this research were driven by one or more collaborations between the researcher and real organisations in the implementation of KET projects.

A multiple case study was the research design adopted, on the basis that more than one application of the new approach to KET would provide a more compelling evidence and would make the overall study more robust (Yin, 2009, p. 53). As part of the multiple case study a total of nine distinct KET projects were conducted in three different organisations. The organisations involved were:

- Cranfield University. Three KET exercises independent from each other were conducted between February 2008 and June 2008.
- A power conversion systems manufacturer, called PowerTech UK Ltd in the context of this research. Five individual implementations of the new approach to KET took place between August 2008 and February 2009.
- A section within a project management organisation in the defence industry, which has been referred to as MoDInfra in this research. A single KET project was conducted between December 2008 and November 2009.

Although this collaboration was described in detail in chapter IV, this chapter will provide more information on how this application of CoMEx fits into the overall study and the data that was collected during the exercise.

Table 5.1 describes the minimum set of data that was sought to be collected and analysed during the implementation of each of the individual KET exercises included in the multiple case study, starting from the collaboration with GTM Ltd. In addition to communication with project participants (resulting in a number of e-mail messages, MS-Office documents, digital images and interview records in the form of voice recordings), the researcher collected valuable data during presentations and whilst developing specific tools such as a fault diagnosis system for GTM Ltd.

Table 5.1. The set of data collected during each of the KET exercises in the field

Project stage	Data collected	Content	Format	Valid for
Initiation and planning of the KET exercise	Communication between researcher and potential participants	Invitations to join the KET exercise	E-mail	CoMEx evaluation: - Motivation to share/acquire knowledge
		Organisation of the KET exercise	E-mail Meeting reports	CoMEx evaluation: - Selection of participants - Selection of the knowledge domain CoMEx implementation: - Potential representation schemes
Preparation of the KET exercise	Communication between researcher and potential participants	Participants' understanding of the knowledge domain	E-mail Interview records	CoMEx implementation: - Initial models - Improving facilitators' understanding of the knowledge domain
		Organisation of the KET sessions: venues, times etc.	E-mail	CoMEx implementation
	Documents	Information about the knowledge domain, reports from previous projects, sample data etc.	MS-Office documents	Improving facilitators' understanding of the knowledge domain

Table 5.1. The set of data collected during each of the KET exercises in the field

Project stage	Data collected	Content	Format	Valid for
Knowledge elicitation and transfer sessions	Photographs	Room before KET session	Digital images	CoMEx implementation: <ul style="list-style-type: none"> - Preparation of rooms for the exercise, i.e. display of initial model etc. CoMEx evaluation: <ul style="list-style-type: none"> - Environmental variables affecting group dynamics
	Photographs	Models developed	Digital images	CoMEx implementation: <ul style="list-style-type: none"> - Use of colour schemes in modelling - Revisiting models as developed when required by the KET team
	Discussions held by KET team	Key issues defining the knowledge domain e.g. operation of gas turbines	Voice recordings	CoMEx evaluation: <ul style="list-style-type: none"> - Group communication - Experts' ability to articulate their knowledge - Modelling as a mechanism for KET - Role of the facilitator - Outcomes of the KET exercise
	Researcher's observation notes	Key issues observed during the group sessions	Text document	CoMEx evaluation: specific incidents related to <ul style="list-style-type: none"> - Issues that influence individuals' comfort zones, such as intrapersonal, interpersonal and environmental variables - Stakeholders' ability to acquire knowledge - The role of the facilitator during the KET sessions

Table 5.1. The set of data collected during each of the KET exercises in the field

Project stage	Data collected	Content	Format	Valid for
Post-process review	Communication between researcher and potential participants	Response to post-process review questionnaire	E-mail Interview records	CoMEx implementation: - Reinforcing learning CoMEx evaluation: - Capturing individuals perception of value of CoMEx immediately after its implementation
Evaluation of KET exercise	Communication between researcher and potential participants	Response to evaluation questionnaire	E-mail Interview records	CoMEx evaluation: - Capturing individuals perception of value of CoMEx some time after its implementation
Reporting the KET exercise	Report of the KET exercise	Researcher's notes on the running and outcomes of the KET exercise	Text document	CoMEx implementation: - Providing the organisation with a summary of the exercise CoMEx evaluation: - Demands of the KET exercise - Outcomes of the KET exercise

As described in chapter III, during the implementation of the multiple case study the data collection process adopted a qualitative research strategy. The analysis of documents and records, interviews and observation, supported by the use of physical artefacts such as flip charts, voice recorders and cameras, were the main research methods used while following the model in figure 5.2.

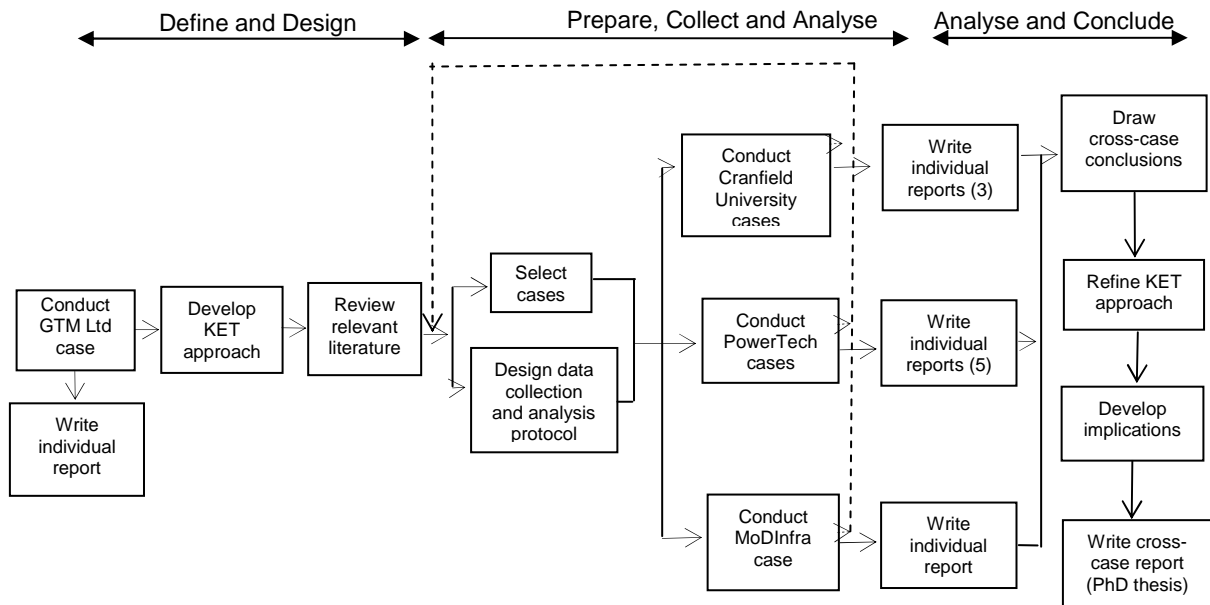


Figure 5.2. The structure of the multiple case study - adapted from Yin (2009, p. 57)

Although the data collection and analysis strategies were driven by the specific issues outlined in section 5.1.1, their implementation was often constrained by the opportunities available. The resources and time required to complete these processes were determined by the complexities of collaborating with three organisations in different locations throughout the UK in KET projects that ran between February 2008 and November 2009.

The remainder of this chapter describes the field work of this research, with emphasis on what data was collected in each organisation. The analysis of the data collected will be carried out in chapter VI.

5.2. The implementation of the data collection process

5.2.1. Introduction

This section focuses on describing the data collection process that enabled the validation of the new approach to KET in the field, using a chronological order.

The description of the data collection process will start with the collaboration with GTM Ltd, which resulted in the first version of CoMEx. The reason for this is twofold:

- It enables the reader to understand better how the idea of KET through collaborative modelling of domain knowledge and CoMEx as a method originated.
- It facilitates the analysis in chapter VI of the data collected during the GTM exercise, as this is still valid for the purposes of assessing the validity of the proposed approach to KET.

Following the outline of the KET project at GTM Ltd, the applications of CoMEx at Cranfield University, PowerTech UK Ltd and MoDInfra will be described. The description will not only include references to what data was collected. It will also highlight how CoMEx evolved as a result of each of its applications in the field, which is summarised in the following table:

Table 5.2. The evolution of CoMEx as a result of the field work

CoMEx version	Origins	Comments
Version 1	GTM Ltd (manufacturing organisation)	Informal mechanism for sharing knowledge while also creating a Bayesian network for fault diagnosis
Version 2	Cranfield University (academic environment)	Method was structured as a result of 3 applications. KET sessions focused on either modelling the domain or analysing individuals' experience Awareness of importance of environmental, interpersonal and intrapersonal variables Raised awareness of the key role of the facilitator
Version 3	PowerTech UK Ltd (manufacturing organisation)	Method was refined as a result of 5 applications. Facilitation: Awareness of the importance of the role of a facilitator Limitations imposed by having a member of the staff as KET facilitator
Version 3 – consolidated (current)	MoDInfra (project management organisation)	No significant changes to the process were made. However, the following issues were better understood: Effects of institutional support in the results of the KET exercise CoMEx as a method is not facilitator-dependent Conclusion: Current version of CoMEx seems reliable.

A concern emerged as a result of combining evaluation and refinement during the field work: would the data collected throughout the field work be compatible if the KET method being studied has changed as a result of its applications?

The researcher understood that data collected across KET exercises remained valid for the purposes of evaluation on the basis of the degree to which CoMEx evolved during the field work. Although it can be argued that CoMEx evolved, the fundamental process behind it remained intact. In other words, the applications of CoMEx in the field allowed the refinement of the method to better implement the same approach to KET.

5.2.2. A word on facilitation

It was foreseen during the definition and design of the multiple case study that the author would possibly need to act as a facilitator of KET exercises during the data collection phase of the research. In order to achieve better results during the implementation of KET exercises the author sought to gradually develop his facilitation skills from early stages of the research through different mechanisms that included:

1. Completing formal training courses that included:
 - a. Research training provided by Cranfield University.
 - b. Performance-based training provided by Dale Carnegie Training in the UK.
 - c. A Diploma in Management provided by the UK Chartered Management Institute.
2. Conducting a review of literature on the topic of facilitation of group meetings.

The literature reviewed covers approaches that focus on the facilitation of the meeting as a process and also the facilitation of the contents of a meeting, as defined by Eden (1990). Approaches such as “the skilled facilitator” (Schwarz et al., 2005) were studied. Also part of the review was the work of authors such as Miranda and Bostrom (1999), Bostrom et al. (1993), Offner et al. (1996) and Anson et al. (1995), who highlight the importance of facilitating both the meeting as an interaction between individuals, and also the content of such interaction.

There is a danger, however, that the limitations in the researchers’ skills as a facilitator might have affected the results of the implementations of CoMEx and, as a consequence, the data collected. In order to minimise this effect, the researcher sought to involve other individuals in the research as KET facilitators whenever it was feasible. This was achieved in applications of CoMEx at PowerTech UK Ltd and MoDInfra. The data analysis in chapter VI will assess the issues related to facilitation of KET exercises.

5.2.3. The origins of CoMEx: Knowledge sharing at GTM Ltd

Introduction

The collaboration with GTM Ltd was the first exercise where data was collected for the assessment and refinement of the new approach to KET. At this stage the researcher was determined to follow a people-based approach to KET, and as a result of this exercise the fundamental principles of CoMEx were outlined.

The problem at GTM Ltd

GTM Ltd designs, manufactures and commissions gas turbines. The company also supports their customers in the service and operation of gas turbines that are already in the field. Gas turbines are large machines and their unexpected downtime can produce significant losses to GTM customers. The company therefore seeks to reduce such downtime to a minimum.

The Help Desk is the point of contact between GTM Ltd and its customers, who are located all around the world. In this interaction GTM Help Desk engineers have developed over many years significant expertise in the operation of gas turbines. That expertise was considered by GTM as an increasingly important component in the design and manufacture of new equipment. However, GTM had not managed to get Help Desk experts to consciously share their expertise with other engineers across the company. In the words of a senior manager at GTM Ltd, “*no mechanism has enabled us to ‘download’ their knowledge to a system for others to use it*”. This was having a negative effect in the work of GTM Ltd, as the company had not been able to transfer its customers’ experience into the design and manufacturing of new products.

The knowledge sharing project at GTM Ltd ran between February 2007 and March 2008, and aimed at eliciting knowledge from Help Desk experts and transferring it to other GTM departments. A summary of its main stages is included in table 5.3 below:

Table 5.3. Key dates and events associated to the KET project at GTM Ltd

Date	Events	Later formalised in CoMEx as
February to May 2007	Initial communication between the researcher and GTM Ltd Discussion of the GTM problems and the proposed solution	Project initiation
May to July 2007	Selection of project participants Document analysis	Project preparation
July to October 2007	Facilitated meetings to create a model of fault diagnosis in gas turbines	Knowledge elicitation and transfer sessions
March 2008	Interviews to project participants	Post-process review

The project implementation

From February to May 2007

The opportunity for collaboration was discussed through an exchange of ideas and documentation between the researcher, his academic supervisor and the manager of the remote monitoring department at GTM Ltd who sponsored the project. This communication took the form of e-mails, telephone conversations and a meeting at GTM Ltd. Part of the data collected at this stage can be found in appendix A, in the folder

GTM Ltd / Original Data Collected / E-mail Communication / Initiation /

From May to July 2007

A second meeting took place, this time involving the researcher, the project sponsor and another three managers, one by each department to be involved in the project. These were: the Help Desk, representing the source of the knowledge to be shared; the control and automation department, a major stakeholder of the knowledge of Help Desk engineers; and the design department, an important stakeholder of that knowledge.

In that meeting the researcher was introduced to the managers by the project sponsor as a project facilitator. The nature of the knowledge domain was discussed. The managers were informed of the priority of the project for the organisation. Ten project participants were selected from the three departments by following the managers' views. The researcher was provided with a number of potentially relevant documents, a sample of which can be found in appendix A, in the folder

GTM Ltd / Original Data Collected / Additional documents provided by GTM /

The researcher was aware of the value of Bayesian networks as a tool to support fault diagnosis in the field of gas turbines operation, based on the work of authors such as Romessis and Mathioudakis (2006), Li (2002) and Pérez-Miñana and Gras (2006). A Bayesian network would provide a framework for modelling the way Help Desk experts identified faults and the probabilities associated to certain root causes of gas turbine failures. A Bayesian network would also provide the basis for the implementation of a remote monitoring system that could support the Help Desk and GTM customers in the fault diagnosis process.

The Help Desk manager understood that a remote monitoring system could help reducing the number of calls they receive from customers, particularly during out-of-hours periods when the on-call engineers are faced with emergency situations developing in remote locations. Therefore he suggested this could be used to motivate his team to actively engage in the exercise.

An initial set of concepts to be included in the Bayesian network were extracted by the facilitator as a result of the initial discussion and the documentation available.

From July to October 2007

Five meetings took place at GTM which involved most project participants. These added a total of just over 9 hours of discussion between team members, which were voice recorded. Sections of those interviews have been included in appendix A, within the folder

GTM Ltd / Original Data Collected / KET Sessions /

While acting as a facilitator of those meetings, participant observation was a key method used by the researcher for collecting data, following the principles outlined in chapter II, section 2.4.3.

There was no clear distinction between the structures of the meetings held. All meetings involved a significant degree of collaborative modelling and also the analysis of participants' experience.

Not all meetings included all engineers initially chosen. In particular, some Help Desk experts were not available at different times given the nature of their work.

The team did not always have a room with all the conditions for a collaborative modelling exercise. Although there always was a board available, at times the team had to discuss the topic sitting around a table.

A Bayesian network was developed, covering the four most common faults in GTM gas turbines. The model included well known failures and also their symptoms, root causes and frequency of the failure modes. A version of the model is presented in figure 5.3. The numerical values associated to the probabilities of nodes in the Bayesian network have been removed in an attempt to improve the readability of the model. Green nodes in the model represent noticeable fault symptoms; orange nodes are associated to faults or failure modes, while white nodes are auxiliary nodes introduced by the researcher to simplify the model for presentation purposes.

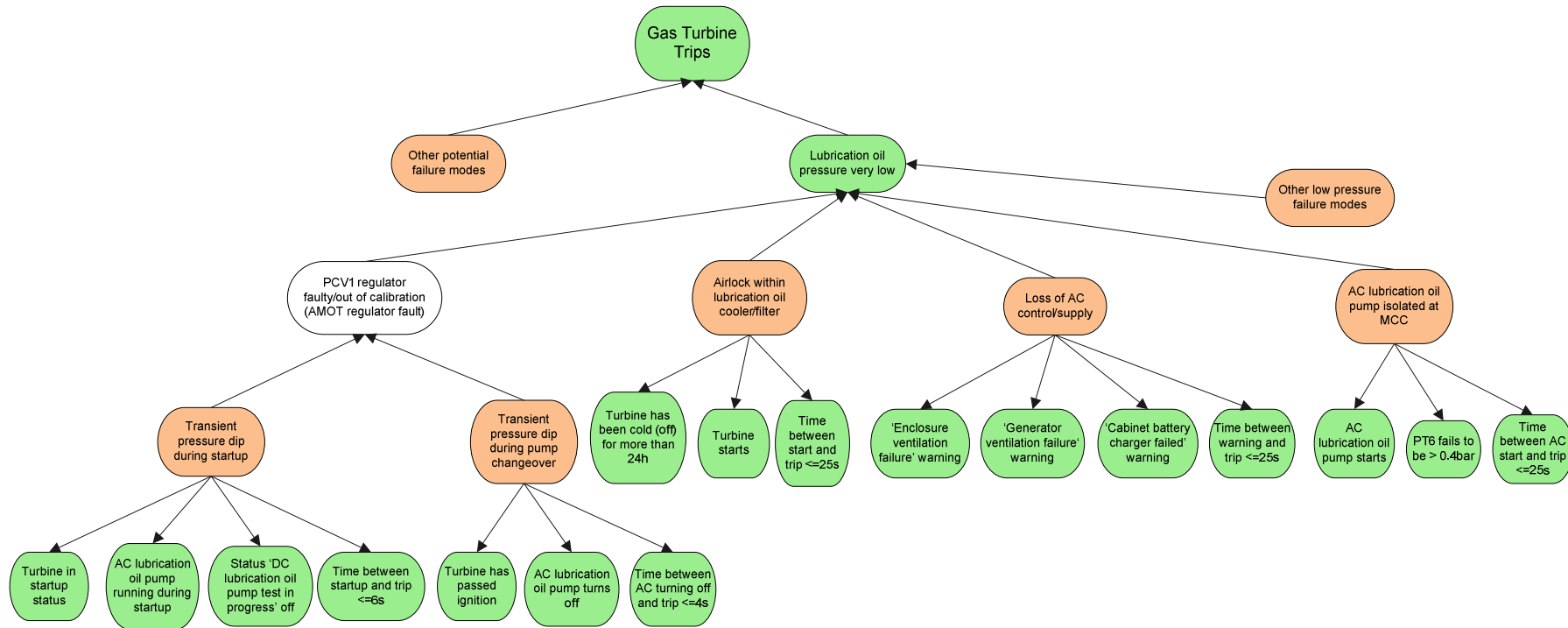


Figure 5.3. A version of the model produced during the KET project at GTM Ltd

At a later stage the researcher used the Bayesian network to develop a fault diagnosis system to be used to draw inferences with regard to the reasons leading to gas turbine failures. Relevant information about the fault diagnosis system produced has been included in appendix A, folder

GTM Ltd / Original Data Collected / Fault Diagnosis System

Part of the communication held during the implementation of the KET sessions has been included in appendix A, within the folder

GTM Ltd / Original Data Collected / E-mail Communication / Implementation /

The outcomes of the project were presented to GTM management in a meeting that also involved the researcher and project participants. The presentation was voice recorded, and the recording is available in appendix A, within the folder

GTM Ltd / Original Data Collected / 20071009_Presentation to Management/

March 2008

The communication that followed the presentation to GTM management aimed at organising a series of interviews to discuss immediate reaction to the application of CoMEx. Such e-mails were collected as a relevant data and these are now available in appendix A, within the folder

GTM Ltd / Original Data Collected / E-mail Communication / Following Presentation /

Four project participants were interviewed on an individual basis. The questionnaire that guided the semi-structured interviews was designed to capture, directly and indirectly, individuals' perception of the value of the KET exercise. It included the following questions:

- Did your understanding of turbine operations change with the discussions?
- Did your view of which are the most common faults related to the lubricant oil pressure change with the discussions?
- Are there problems related to lubrication oil pressure which you would now respond to differently?

- Have you changed your view of the kind of expertise that there is in the help desk?

These interviews were voice recorded, adding over 50 minutes of data to those already collected. The recordings of these interviews are available in appendix A, folder

GTM Ltd / Original Data Collected / Evaluation Interviews /

Conclusion

By March 2008 the collaboration with GTM Ltd was concluded. An initial version of CoMEx (version 1) was outlined and could then be applied in other contexts. The key issues that became clear in this version of CoMEx are summarised in table 5.4.

Table 5.4. Key issues that emerged from the KET project at GTM Ltd

Stage	Key issues
Project initiation	Importance of organisation's perception of its need for KET: expertise that needs to be shared, its sources and stakeholders Building a system that facilitated their work was a successful mechanism to motivate experts to actively participate
Knowledge elicitation and transfer sessions	Collaborative development of a Bayesian network is a successful mechanism to share knowledge across departments

Thus, the research would seek to address the following dimensions in future applications of CoMEx in the field in an attempt to improve the current version of the method:

- How to conduct the project preparation
- The nature and focus of the KET sessions
 - What makes a successful facilitation and how can it be achieved?
 - How many sessions were adequate and what would be the focus of each session?
 - What is an adequate length for each session?
 - What types of knowledge can be targeted in these sessions?
 - What models could be adequate for other types of knowledge?
- Facilitation of KET sessions

5.2.4. The formalisation of CoMEx: KET at Cranfield University

Introduction

Once its principles had been delineated as a structured approach to knowledge elicitation and transfer, the first applications of CoMEx took place in a research-based organisation. Cranfield University is an academic institution where a significant number of individuals conduct PhD research in science, technology and management fields.

The problem at Cranfield University

Authors such as Golde (2000), Lovitts (2001) and Hockey (1994) have noted that around 50% of doctoral students do not complete their programs. Among the main reasons behind such high levels of PhD student attrition is the fact that PhD students suffer from a misconception about research and in particular of the PhD research process, which has been studied by authors such as Meyer et al. (2005).

Cranfield University is not exempted from these problems. Improved ways of learning about the PhD research process from supervisors and other researchers could help Cranfield University achieve better levels of completion of PhD research. Additionally, the researcher was aware of the limitations in the interaction between PhD students and in particular with staff who could provide support in relation to their research processes. Isolation, as pointed by Ali and Kohun (2006), is another major cause of PhD researchers' attrition.

Through interaction with a number of academics and PhD researchers at different departments it was possible to organise a series of KET projects. These exercises were relatively informal in the sense that no official institutional support was needed.

Three projects were implemented between February and June 2008. Each project needed approximately one month to be completed. The researcher is not aware of any exchange of experiences between participants in any two of these KET exercises. On the basis of their ways of working, the differences in the nature of their research and the location of their offices, the researcher understands that participants in each exercise were not aware of any other of the KET projects.

Table 5.5 summarises the key dates and events that characterised each of the KET projects at Cranfield University.

Table 5.5. Key dates and events associated to the KET projects at Cranfield University

Date	Event
KET Project I: February to April 2008	
4 February to 11 March 2008	Project initiation
11-20 March 2008	Project preparation
21 March 2008	Knowledge elicitation and transfer meeting I – collaborative modelling
9 April 2008	Knowledge elicitation and transfer meeting II – collaborative modelling and experience analysis
15 April 2008	Post-process review
KET Project II: April to May 2008	
3-6 April 2008	Project initiation
6-30 April 2008	Project preparation
30 April 2008	Knowledge elicitation and transfer meeting I – collaborative modelling
7 May 2008	Knowledge elicitation and transfer meeting II – Experience analysis
16 May 2008	Post-process review
KET Project III: June 2008	
5 June 2008	Project initiation
5-9 June 2008	Project preparation
21 June 2008	Knowledge elicitation and transfer meeting – collaborative modelling and experience analysis
20 June 2008	Post-process review
KET Projects I, II and III	
30 November 2008	Evaluation - Only for the purposes of this research

On the applications of CoMEx at Cranfield University

The knowledge domain to be discussed in all KET exercises at Cranfield University was the process of conducting a PhD research and its main challenges.

Domain experts would be academic PhD supervisors, PhD holders and Student Monitoring staff from the Academic Registry department. Stakeholders would be Cranfield University PhD researchers from a range of areas within science, technology and management. As an average, KET exercises included 4 stakeholders and two experts. The researcher acted as a facilitator in all three exercises.

Experts were invited to contribute their research experience in a series of meetings that aimed at supporting researchers who strive to conduct their PhD process due to a lack of a formal, continuous support. Once experts had agreed, PhD research students were invited to attend the meetings.

Although they focused on a similar domain, each of the three KET teams produced a different model of the PhD research process based on their experience. These are included in figures 5.3 to 5.5 below.

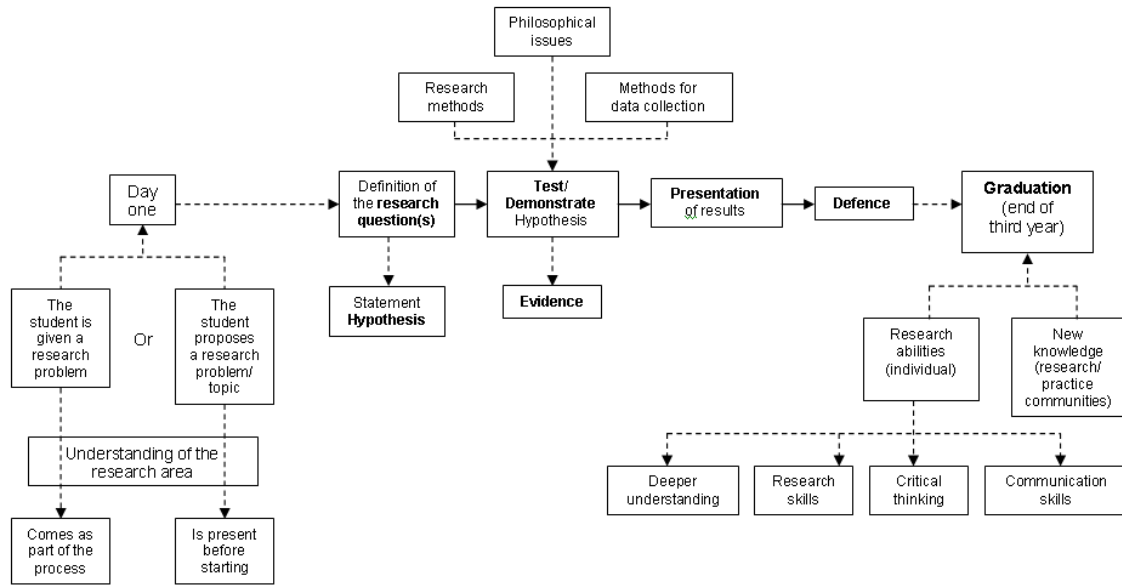
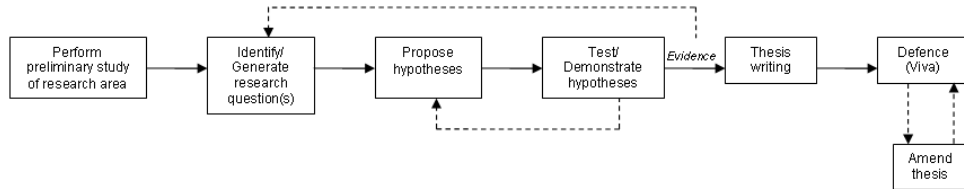


Figure 5.4.a. First model of the PhD process developed by the KET team in project I at Cranfield University

The PhD process: A research training process based on successfully investigating a research question.



Key concepts associated with the PhD process:

Research:

- Study
- Hypotheses
- Hypotheses generation
- Hypotheses testing
- Research questions
- Evidence
- Thesis
- Writing
- Defence
- Amendments

PhD involves:

- A research project
- Generation of new knowledge
- Research training
- A problem-solving process
- Critical thinking
- Independent research
- Presenting results
- Communication
- Understanding of research
- Deep understanding of research area

Figure 5.4.b. Second model of the PhD process developed by the KET team in project I at Cranfield University

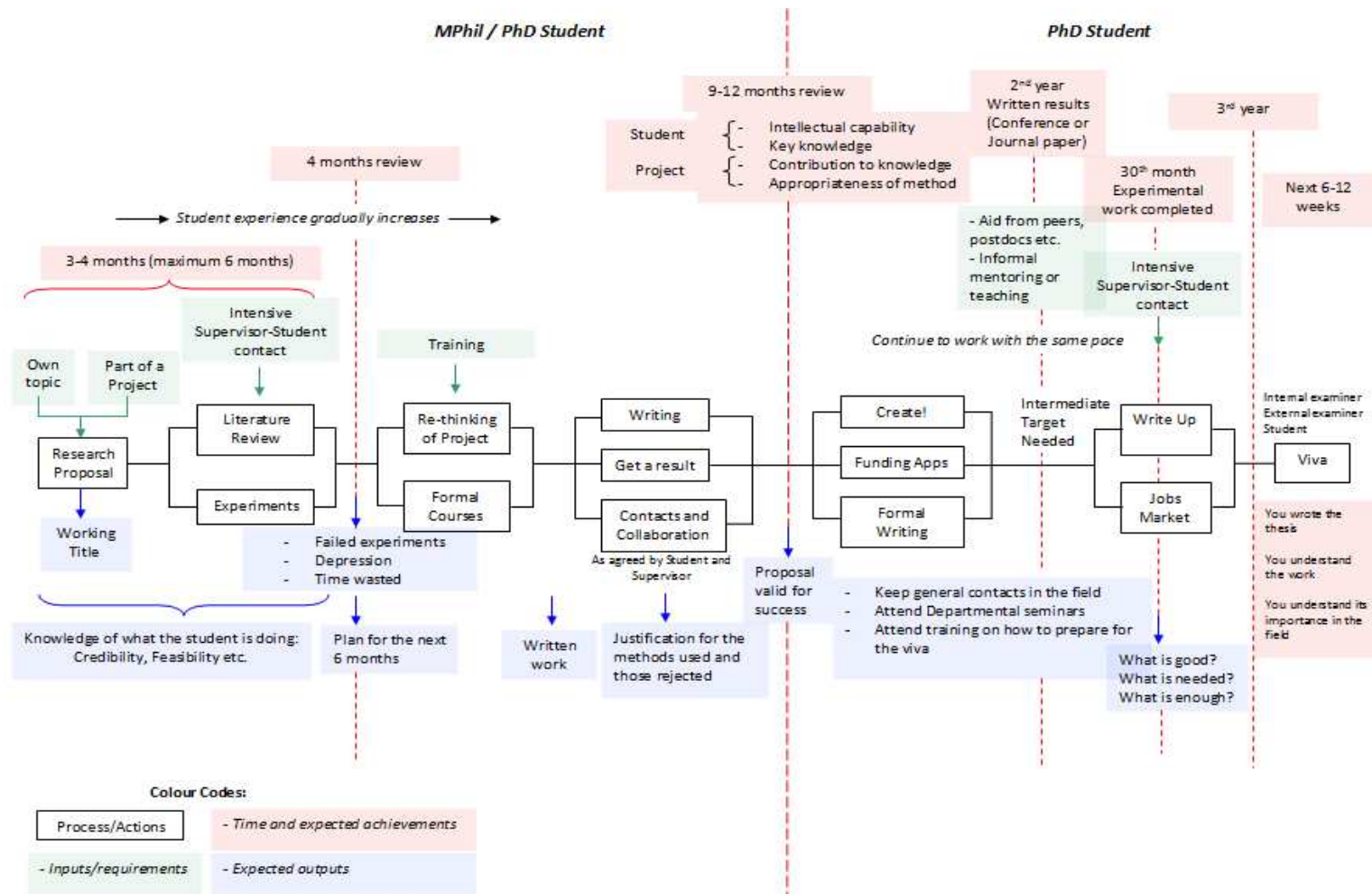


Figure 5.5. Model of the PhD process developed by the KET team in project II at Cranfield University

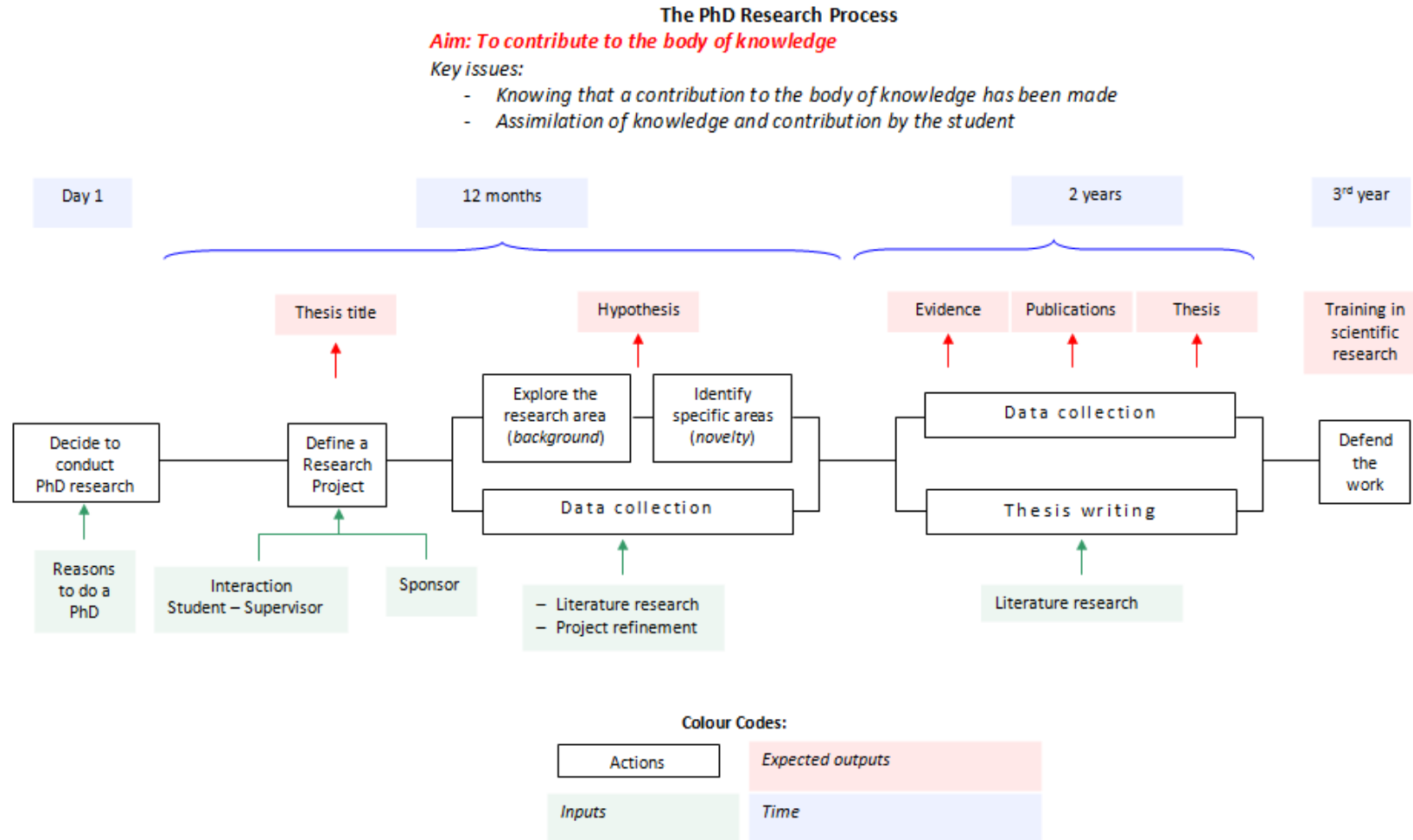


Figure 5.6. Model of the PhD process developed by the KET team in project III at Cranfield University

Changes that led to version 2 of CoMEx at Cranfield University

During the applications of the first version of CoMEx at Cranfield University some changes were made to the process originally designed at GTM Ltd. These changes have been grouped according to the CoMEx stage as described below.

Project preparation

The notion of an initial model of the knowledge domain was introduced in the second KET project at Cranfield University. The model proposed by the facilitator to participants in the second project is included in figure 5.7.

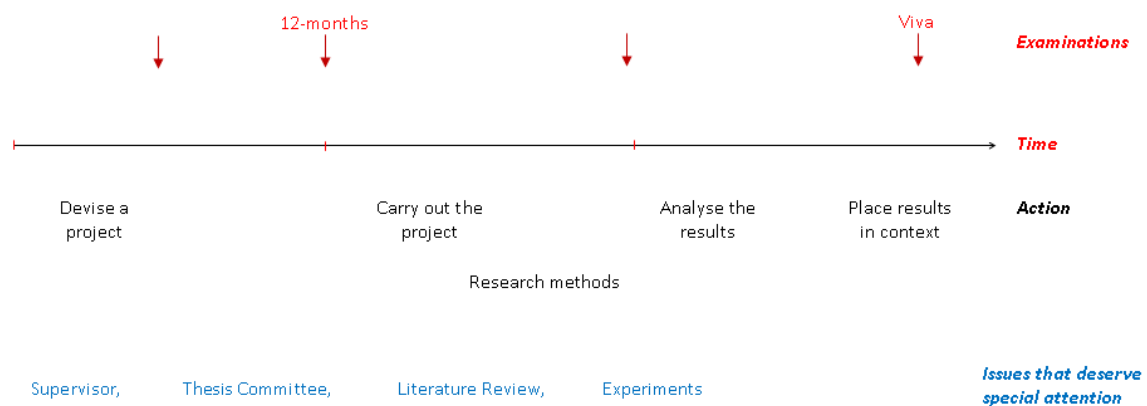


Figure 5.7. Initial model of the PhD research process, designed by the facilitator based on initial set of concepts extracted from participants in KET project II at Cranfield University

Knowledge elicitation and transfer sessions

The starting point of the meetings:

Starting from the second exercise at Cranfield University the KET sessions started with a model of the domain presented by the facilitator to the KET team when they arrived to the room. Then the KET moved on to different activities depending on the type of meeting.

Different types of meetings:

Following the structure of the GTM project, the two meetings of the KET team held during the first KET project at Cranfield University had a similar purpose: modelling the knowledge domain. Hence two different models of the same domain were produced by the same team, as presented in figure 5.4.

The idea of separating modelling from experience analysis was introduced in the second KET project. While the first knowledge elicitation and transfer session was fully dedicated to modelling, the second session was dedicated to encouraging experts to give feedback to each stakeholder on the basis of the model produced.

The notion of more than one type of KET sessions was successful. Therefore, it was formalised in the definition of CoMEx by separating the KET meetings into modelling sessions and experience analysis sessions.

Spatial arrangements:

In the first KET project at Cranfield University participants were sitting around a table with a clear view of the board where the model was being developed. During the second KET project the idea of different layouts, as shown in figures 5.8 and 5.9 below, was tried successfully.

A U layout for collaborative modelling meetings, with individuals sitting side by side as described by Sommer (1969) was found to facilitate individuals' contributions to the development of models. The absence of desks was found to discourage note-taking during the meeting, thus having a positive effect in participation.

A face-to-face layout described by Russo (1969) was found to work better for the purpose of having an exchange of ideas about each other's areas of expertise during the expertise analysis sessions.

These arrangements were therefore introduced in the definition of CoMEx.



Figure 5.8. The room prepared for the first knowledge elicitation and transfer meeting in KET project II at Cranfield University



Figure 5.9. The room prepared for the second knowledge elicitation and transfer meeting in KET project II at Cranfield University

Environmental variables:

An incident during the second KET exercise raised the facilitator's awareness of the importance of considering environmental variables during the KET sessions. One of the participants joined the meeting late and had his lunch during the course of the meeting.

This event distracted the rest of the team and inhibited the participation of other participants, particularly those sitting next to him, during the rest of the meeting. As a consequence, more emphasis was put in considering the physical environment of the KET group.

Environmental variables such as territoriality, spatial arrangements and interpersonal distance are usually determined by individuals' personal, social and situational variables (Shaw, 1981, p.143). In order to address the potential effects of seating preferences of different individual participants, the researcher sought to ensure that in further KET exercises all individuals had the opportunity to choose their preferred location. Also, by having extra seats available, the researcher sought to allow team members to change their positions in the group during the course of the sessions if their seating preferences changed.

Intrapersonal variables:

During one of the KET exercises the level of participation was unbalanced. The meeting was significantly influenced by the views of only one of the individuals involved, as the person contributed to more than 80% of the discussion. While this was not highlighted by participants as a negative issue, it did emphasise the importance of considering the personal characteristics of participants for success of the project.

Facilitation:

Having one exercise heavily influenced by the views of one individual suggested that more emphasis was needed in clarifying the role of the facilitator and the required skills. The exercise raised the researcher's awareness of the importance of facilitators' ability to deal with individuals from different backgrounds and characteristics, including not only dominant talkers but also shy participants.

Modelling:

In the first KET project at Cranfield University the representation schemes used were heavily influenced by the facilitator's experience at GTM. However, in the second KET project a timeline was used as a different representation scheme for the initial model, as shown in figure 5.7. Additionally, the notion of colour codes for the modelling session was successfully introduced in the second KET project.

On the data collected

Following the structure outlined in table 5.1, all the data collected during each of the 3 KET exercises at Cranfield University are included in appendix A, within the folder

Cranfield University / Original Data Collected / CoMEx - Exercise [1..3] /

E-mail was used by the facilitator and KET teams during the Cranfield University projects as the main communication mechanism. Using the e-mail the facilitator organised the meetings and interviews, booked rooms, reminded participants of dates, times and venues and later shared the outcomes of the knowledge elicitation and transfer sessions with projects participants.

Interviews were held with participants at different stages of the KET process. The questionnaires used for these interviews were designed to support KET and also to collect data that was relevant for the evaluation and refinement of CoMEx. Such questionnaires included questions such as the following:

- Did your understanding of the process of conducting PhD research change with the discussions?
- Did your view of which are the most common problems related to the PhD research process change with the discussions?
- Are there particular issues that you would now do or avoid?
- Had you discussed the same issues as were covered in the meetings with a supervisor or other PhD students at any stage?
- Has this exercise affected your conception of the PhD process?
- Could the meetings have been run in a different way?

Many interviews were voice recorded, providing over 3 hours of data in electronic format. The interview recordings and their transcriptions are available within the corresponding folders in appendix A.

KET meetings were also voice recorded, adding approximately 7 hours of data to those already collected. These voice recordings are available in appendix A. Observation during the exercises and notes taken after each meeting became a significant source of data.

Photographs of the rooms were taken before each meeting started and after it finished. Some of these photographs are also available in appendix A, within the folder corresponding to each KET session.

A report was produced after each individual KET exercise. The nature of such reports is a descriptive one. The reports, also available in appendix A, were used to understand and compare different exercises.

Conclusion

In July 2008 the initial version of CoMEx had been formalised, validated and refined through 3 applications in an academic environment. As a result of such process the knowledge elicitation and transfer method was structured in four distinct stages and the following issues had been addressed and at least partially resolved:

Table 5.6. Key lessons learned from the application of CoMEx (v1) at Cranfield University

Stage	Key issues
Project preparation	It is important to have an initial model of the knowledge domain to kick off the KET sessions if needed
Knowledge elicitation and transfer sessions	<p>There are two main objectives to be covered during the sessions. These are: collaborative modelling the knowledge domain and analysis of individuals' experience.</p> <p>The facilitator plays a key role in the success of the KET sessions</p> <p>In order for the meetings to be successful, KET facilitators can start every meeting by presenting a model of the knowledge domain to the KET team.</p> <p>In certain circumstances, one KET meeting could be enough to run a successful KET exercise.</p> <p>It is essential for the success of KET meetings that environmental, interpersonal and intrapersonal variables are taken into account by the KET facilitators.</p>

Version 2 of CoMEx had been developed and was ready to be implemented in an industrial setting with the aim of addressing the following dimensions for its refinement:

- Facilitation: Does success of CoMEx depend on the researcher's involvement as a facilitator?

- Individuals' response to the KET process: Would individuals from non-academic environments engage in all the stages of the KET process as they did at Cranfield University?

5.2.5. Moving into an industrial setting: KET at PowerTech UK Ltd

Introduction

On conclusion of the Cranfield University project the main features that define the current version of CoMEx had been outlined. Opportunities to validate and further refine its principles in an industrial setting were then explored.

PowerTech UK Ltd will be the term used in this dissertation to refer to the UK unit of a world-wide organisation that specialises in the tendering, design, manufacture, commissioning and service of power conversion systems. PowerTech UK Ltd delivers engineering solutions for markets that include Marine, Oil & Gas and Industry. Beyond the production of system components such as rotating machines, variable-speed drives and automation and controls, PowerTech UK Ltd focuses on optimising the interfaces between them. Concretely, this means that each employee is encouraged to find the best customised solutions for each customer, taking a global approach to power conversion rather than simply trying to sell existing packages.

Service engineers at PowerTech UK Ltd have gained, in their daily dealing with customers across the world, a significant expertise in relation to all types of products developed by the company over many years. That expertise has now become one of the key selling factors of PowerTech UK Ltd. As a consequence, the organisational structure has been modified to have Service engineers working directly with other engineers that specialise in the same market area.

The problem at PowerTech UK Ltd

PowerTech UK Ltd has become increasingly aware of the potential effects of the experience of its Service engineers and the documentation they generate on a daily basis on the company's efficiency and its ability to innovate. However, only a fraction of that experience was being shared by Service experts with engineers from other departments, despite the changes made in the organisational structure.

On a separate but related topic, its aim to provide customised solutions for customers' success has resulted in a variety of approaches across PowerTech UK Ltd to dealing with customer queries. Different teams, and in particular Service teams, deal with customers in different ways with varying levels of success. A KM team had been recently created at PowerTech UK Ltd as part of its development strategy to address this and other knowledge-related problems that affect the competitiveness of the company. One of the areas where the team needed to gain a significant understanding in a relatively short period of time was the ways of working of Service engineers across PowerTech UK Ltd. Equally important for the KM team to understand was the nature of the knowledge base available to Service engineers and its limitations. Knowledge about these two areas would facilitate the definition of the long-term KM strategy of the company.

In July 2008 the researcher started working for PowerTech UK Ltd as part of such KM initiative. The researcher presented the new knowledge elicitation and transfer approach to members of the KM team. It was agreed that CoMEx would become part of the range of tools available for the team to address the dual challenge of outlining its future plan while also fostering the sharing of Service engineers' knowledge with other individuals and workgroups across the company.

Between August 2008 and March 2009 CoMEx was applied in five different occasions at PowerTech UK Ltd. Only one of those KET projects was being run at any given point in time. On the basis of their location within the business, the researcher understands that at the time of their participation in a KET exercise the project participants were not aware of any other application of CoMEx.

Table 5.7 summarises the key dates and events that characterised each of the KET projects at PowerTech UK Ltd:

Table 5.7. Key dates and events associated to the KET projects at PowerTech UK Ltd.

Date	Event
August 2008	Project initiation: common to all projects
KET Project I: August to November 2008	
August to 10 November 2008	Project preparation
4 November 2008	Knowledge elicitation and transfer meeting – collaborative modelling and experience analysis
19 November 2008	Post-process review
KET Project II: August to December 2008	
August to 13 December 2008	Project preparation
13 December 2008	Knowledge elicitation and transfer meeting – collaborative modelling and experience analysis
6 January 2009	Post-process review
KET Project III: August 2008 to January 2009	
August 2008 to 8 January 2009	Project preparation
8 January 2009	Knowledge elicitation and transfer meeting – collaborative modelling and experience analysis
19 January 2009	Post-process review
KET Project IV: August 2008 to January 2009	
August 2008 to 13 January 2009	Project preparation
12 January 2009	Knowledge elicitation and transfer meeting – collaborative modelling and experience analysis
20 January 2009	Post-process review
KET Project V: August 2008 to February 2009	
August 2008 to 13 February 2009	Project preparation
13 February 2009	Knowledge elicitation and transfer meeting – collaborative modelling and experience analysis
17 February 2009	Post-process review

On the application of CoMEx at PowerTech UK Ltd

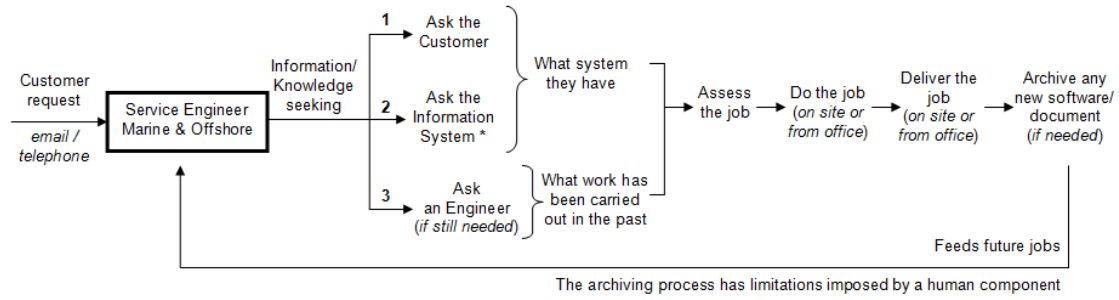
The knowledge domain to be discussed in all exercises was the process of addressing a PowerTech customer query. Also important would be the information and knowledge that service engineers used during such a process and the challenges they faced in finding, retrieving and using those resources. The facilitator sought to motivate participants by capitalising on the latter, as it could potentially bring direct benefits to their daily working practices.

While service engineers were the domain experts at PowerTech, stakeholders fell into the following categories:

- Those that benefitted from learning about the process of dealing with customer queries. In this case, new engineers working for different departments across PowerTech UK Ltd as part of a Graduate Scheme.
- Those that benefitted from learning about the information and knowledge-related challenges that service engineers have to deal with as part of their work.

The researcher was a full-time PowerTech employee, member of its KM team, at the time of the KET exercises. He participated in three out of the five KET exercises in a dual role of KET facilitator and stakeholder of the knowledge of engineers. Another member of the KM team at PowerTech also participated in all exercises as a stakeholder. As a consequence of their participation, it is difficult to argue that KET exercises at PowerTech were totally independent from each other. However, as he was aware of the importance of originality of the data collected, the researcher always sought to avoid making any explicit reference to other KET exercises. The second member of the KM team also ran some KET exercises in the role of facilitator. He was made aware of the importance of avoiding references to other exercises.

Although all exercises focused on a similar domain, five different sets of models were produced, based on the experience of each KET team and the set of information resources they use on a regular basis. The models are included in figures 5.10 to 5.14 below.



* The company Information System could be queried from office or home if the engineer is on call. If from home, there are technical limitations imposed by the speed of connection.

Figure 5.10.a. The process model developed by the first KET team at PowerTech UK Ltd

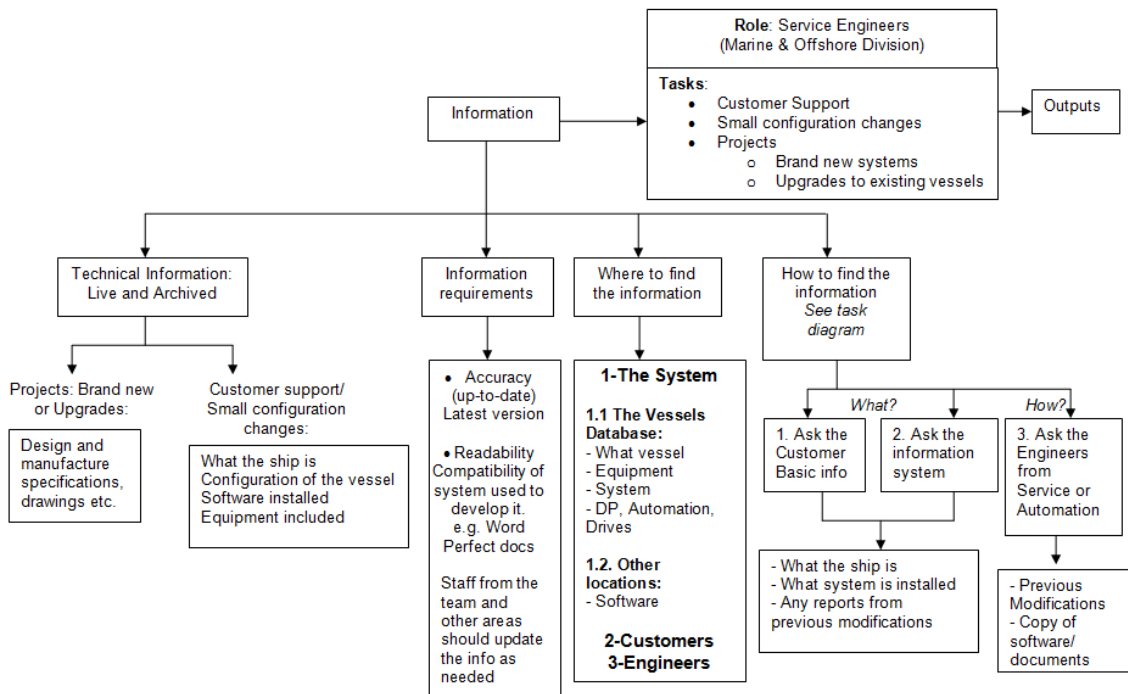


Figure 5.10.b. The information model developed by the first KET team at PowerTech UK Ltd

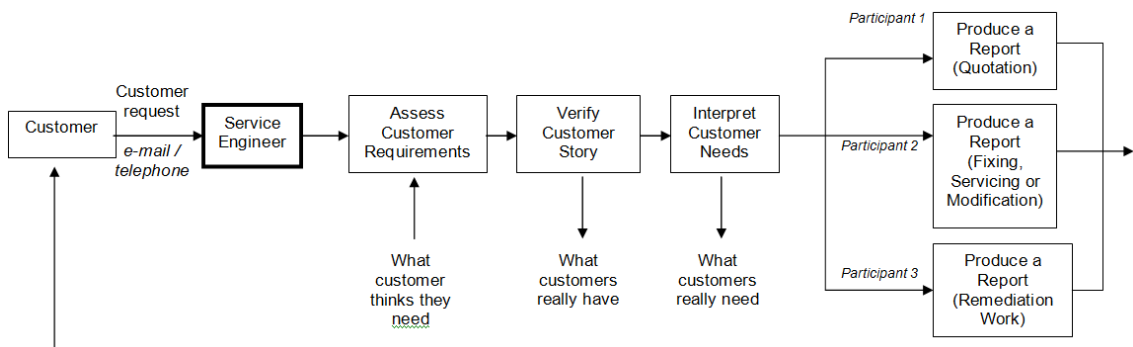


Figure 5.11.a. The process model developed by the second KET team at PowerTech UK Ltd

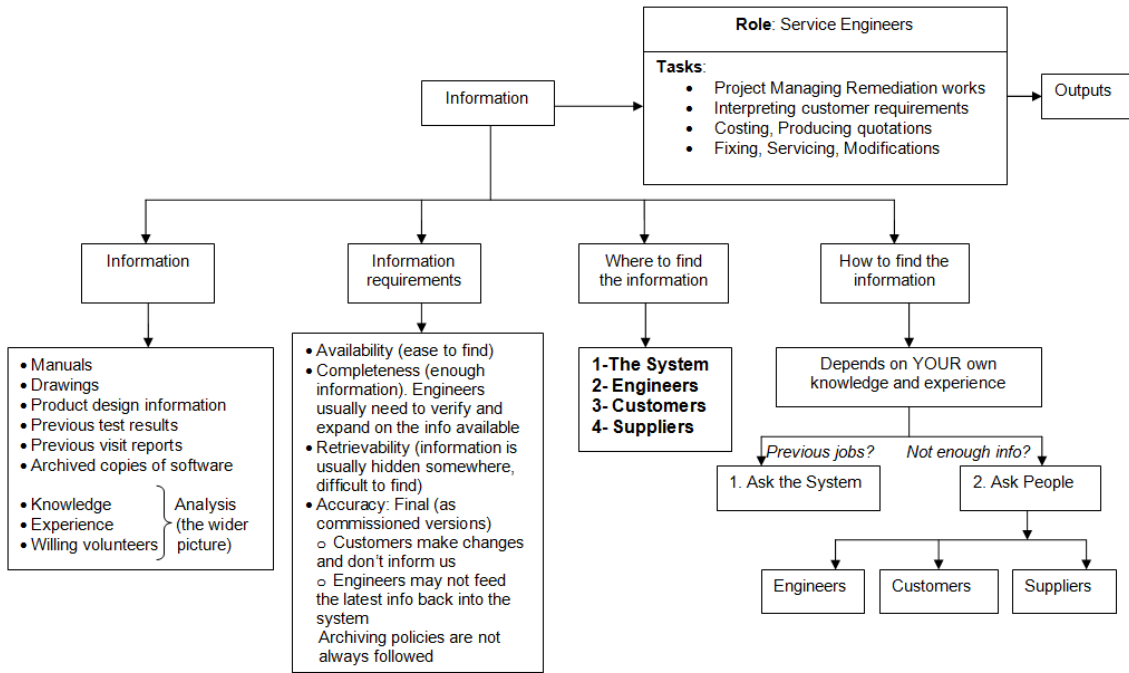


Figure 5.11.b. The information model developed by the second KET team at PowerTech UK Ltd

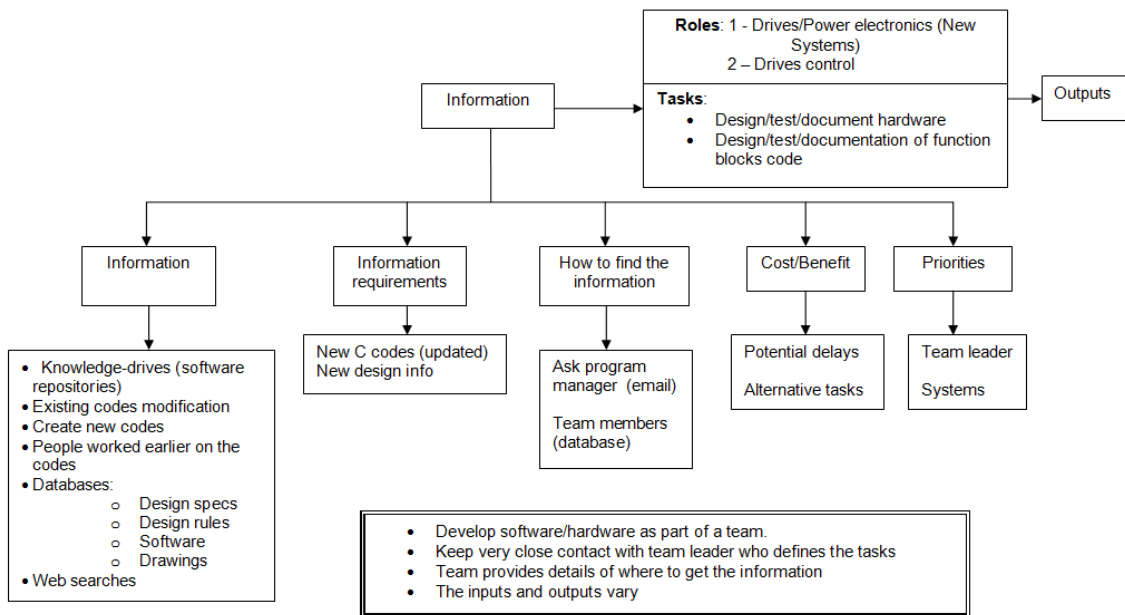


Figure 5.12. The process-information model developed by the third KET team at PowerTech UK Ltd

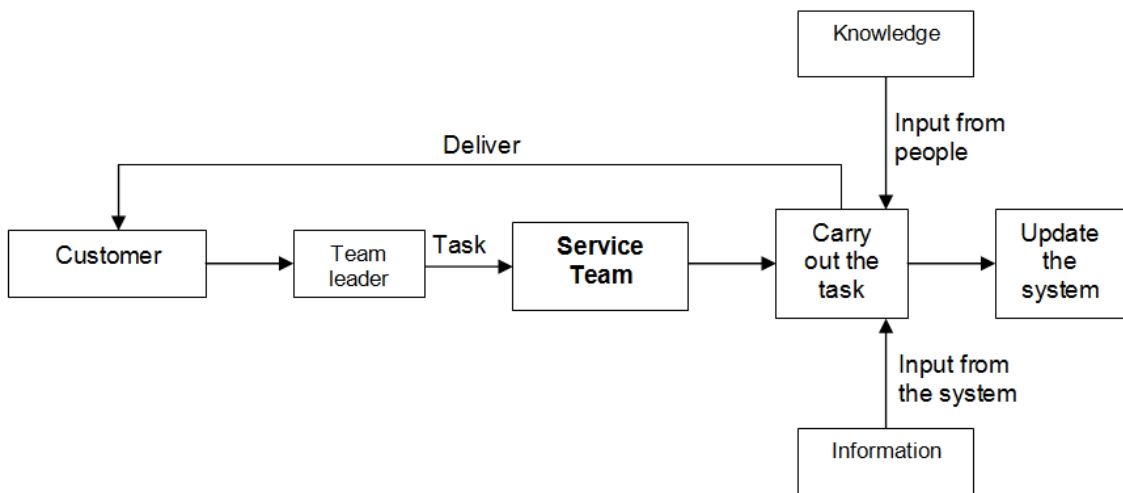


Figure 5.13.a. The process model developed by the fourth KET team at PowerTech UK Ltd

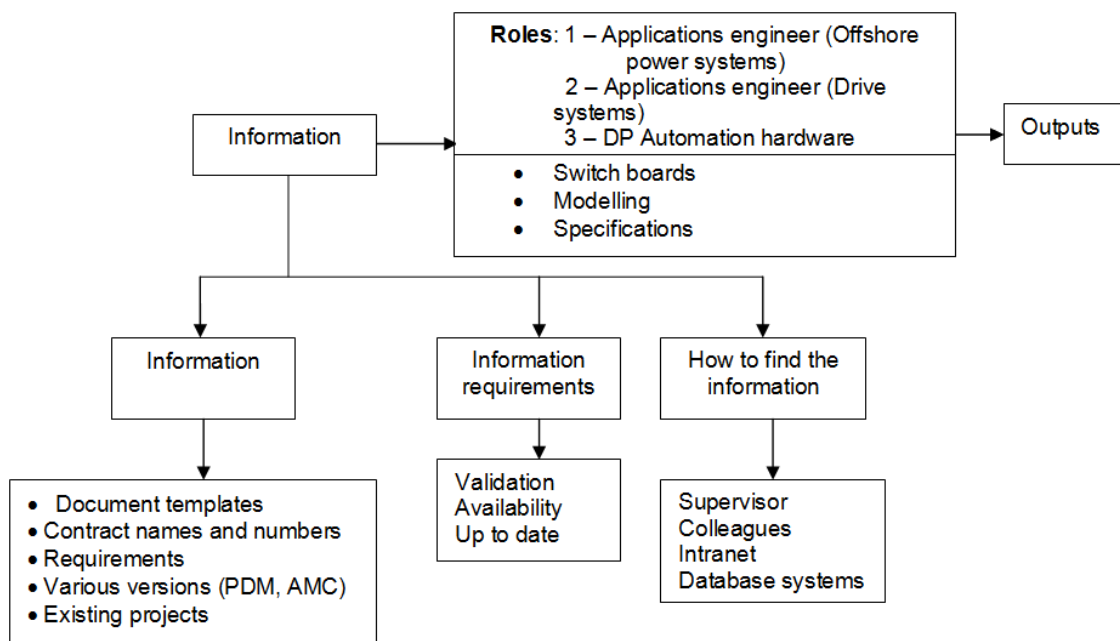


Figure 5.13.b. The information model developed by the fourth KET team at PowerTech UK Ltd

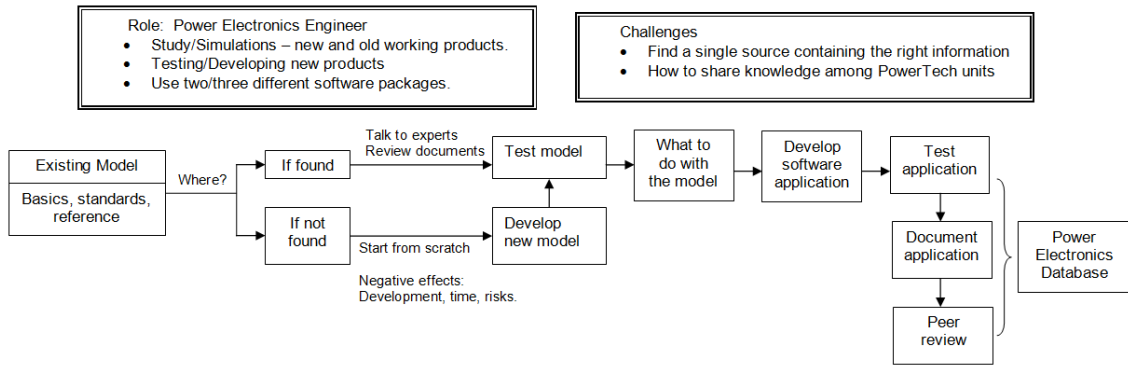


Figure 5.14. The process-information model developed by the fifth KET team at PowerTech UK Ltd

Changes that led to version 3 of CoMEx at PowerTech UK Ltd

Project initiation

No explicit support from management was sought for the implementations of CoMEx at PowerTech UK Ltd. Once the KM team agreed that CoMEx would be used, the facilitator approached potential participants with the aim of organising the KET exercises. The effect of this on the implementation of CoMEx and the data collected was twofold:

- On the one hand, engineers did not see the exercise as a management initiative and were therefore more willing to actively engage in the KET projects.
- On the other hand, the researcher did not have a budget to cover the time that engineers spent in the KET exercises and as a result the projects were run within the minimum timescale possible. This meant that all projects were reduced to one knowledge elicitation and transfer session.

Project preparation

After interviewing all potential participants a single model was created by the KET facilitator using the concepts extracted from the interviews and the documentation reviewed. This model, presented in figure 5.15, was used as the initial representation of the knowledge domain in all applications of CoMEx at PowerTech UK Ltd.

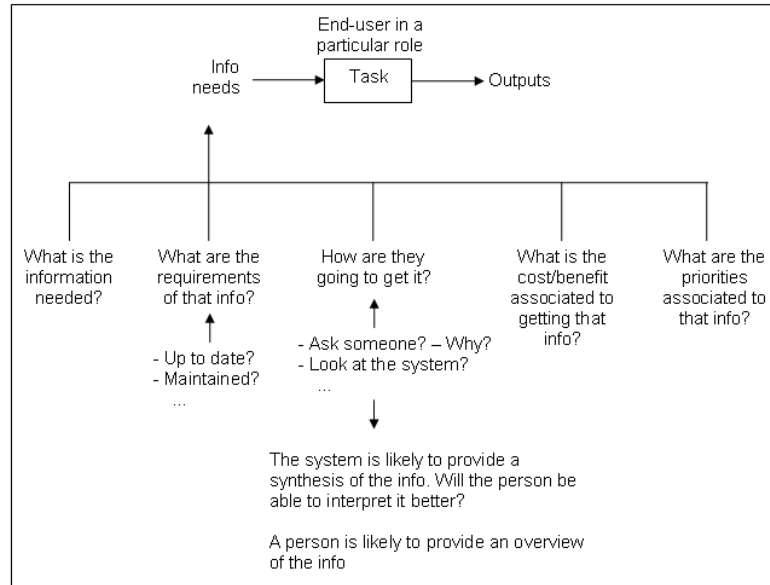


Figure 5.15. The process-information model: Initial model developed by the KET facilitator during the preparation stage at PowerTech UK Ltd

The facilitator had the opportunity to familiarise with PowerTech UK Ltd and its information system, thus exploring the resources mentioned by the engineers being interviewed and recording, in the form of notes, all significant details observed.

A significant effort was put at this stage in training a member of the KM project in the running of CoMEX so that he could run at least one of the KET exercises. Such training was based in three different actions:

- Review of documentation related to CoMEX and its previous applications, as well as the bibliography on group dynamics and facilitation techniques.
- Individual, one to one meetings where the researcher provided details on the fundamentals of the KET process.
- Participant observation of how CoMEX was run in the KET exercises facilitated by the researcher.

After participating in three applications of CoMEX as a stakeholder the individual being trained felt confident that he would be able to facilitate an implementation of CoMEX.

Knowledge elicitation and transfer sessions

Each application of CoMEx at PowerTech UK Ltd included only one knowledge elicitation and transfer meeting in which the model was developed and also used to discuss the experience of participants in the domain of customer service.

There was a large table in the conference rooms used for the KET exercises. Participants seated in U and circle layouts around the table, and this was added to the definition of CoMEx.

The fourth KET exercise was facilitated by the member of the KM team that had been previously trained, while the researcher participated as a stakeholder. Despite the efforts made in the preparation of that individual, two main issues had a limiting effect in the success of this exercise. These were:

- Underestimating the importance of the role of the facilitator in leading the group through a collaborative knowledge modelling exercise.

As a result, the researcher had to intervene and provide support to the facilitator in encouraging participants to contribute their knowledge during approximately ten minutes of the KET session.

- Assuming that the maximum value of applying CoMEx would have been already achieved on completion of the KET sessions.

As a result, the post-process review stage was not carried out, no further documentation was produced by the facilitator and there was no communication between the facilitator and project participants after the KET sessions.

The fifth KET exercise ran with only one expert and two stakeholders. The KET session still achieved its aims of developing the model and discussing the experience of the three participants.

Post-process review

Despite the continuous requests by the facilitator, responses from individual participants to the questionnaire provided were scarce and took longer than in previous applications of CoMEx. Also, participants in the KET exercise facilitated by the second member of

the KM team were not approached by the facilitator after the KET sessions. As a consequence, no data was collected at this stage in such exercise.

On the data collected

This series of KET exercises took place during the period in which the global economy suffered a major downturn, which had an effect in engineering companies including the PowerTech Group. The KM team was advised that any form of evaluation of individuals and processes could be perceived as a potential source of information for management to make decisions that could affect the staff directly. This had a negative effect in the amount of data that was collected, in particular the use of voice recording while interviewing engineers on an individual basis.

The data collected during the five applications of CoMEx at PowerTech UK Ltd following the principles outlined in table 5.1 are included in appendix A, within the folder

PowerTech UK Ltd / Original Data Collected / Exercise [1..5] /

The perceived lack of management support that resulted from presenting the application of CoMEx as an initiative of individuals within the KM team had a negative effect in the response from participants to requests for feedback and therefore on the amount of data collected.

The facilitator interviewed a total of 21 engineers, some of them more than once at different stages of the implementation of CoMEx. A number of these interviews were voice-recorded.

All KET meetings were voice-recorded, adding a total of 6 hours and 34 minutes to the data collected.

The researcher took notes after all KET sessions where he acted as a facilitator, and during and after the session facilitated by the other person.

Photographs of the room and models developed were taken during each exercise, and a report was written and made available to the company (i.e. the KM team) on completion of most exercises. A report was not written after the implementation of the exercise facilitated by the second member of the KM team.

Conclusion

With the application of CoMEx at PowerTech UK Ltd, the KET method had been substantially refined, while the practicalities of its implementation had become clearer.

The following issues related to CoMEx were learned at PowerTech UK Ltd:

Table 5.8. Key lessons learned from the application of CoMEx (v2) at PowerTech UK Ltd

Stage	Key issues
General – all stages	The lack of explicit institutional support has a negative effect in individuals' response to the demands of the KET exercise, even when these are sought to be minimised.
Knowledge elicitation and transfer sessions	While success of the KET sessions does not depend on the researcher, there are a set of skills and commitments required from the individual who facilitates CoMEx.

Any further application of CoMEx, now in its version 3, would look at learning more about the issues related to facilitation of KET sessions. Additionally, variation of other aspects of the method such as the number of meetings and their duration would provide a better understanding of the aspects that could affect the success of the process.

5.2.6. CoMEx in a project management context: KET at MoDInfra

Introduction

On completion of the KET exercise at PowerTech UK Ltd, CoMEx had been applied in 8 specific KET projects within two different organisations. The researcher understood, however, that the processes of refining CoMEx and assessing its value would still benefit from its application in other types of organisations.

A collaboration was established with a project management organisation that had been recently created within the Ministry of Defence with the aim of delivering the infrastructure required by personnel in the battlefield. The organisation has been referred to in this dissertation as MoDInfra. The collaboration with MoDInfra provided the basis for further refinement of CoMEx and the collection of relevant data. A detailed description of the implementation of CoMEx at MoDInfra was provided in chapter IV, section 4.3.

How version 3 of CoMEx was consolidated at MoDInfra

Version 3 of CoMEx did not change significantly as a result of its implementation at MoDInfra. However, this project provided an opportunity for learning in different areas of the method. These areas are described in this section, organised according to the CoMEx stage where they belong.

Project Initiation

Management support: The implementation of CoMEx at MoDInfra had full support from the organisation leaders. CoMEx was presented as a ‘team building exercise’ and therefore all resources were made available. As a consequence, the project enjoyed full support also from participants.

Project preparation: The facilitator did not have the opportunity to meet all project participants prior to the first KET meeting. In the meantime, a large part of the communication was based on the use of the e-mail.

Knowledge elicitation and transfer sessions

Duration of the meetings: The length of the sessions was significantly different in the MoDInfra exercises, with the KET team spending three full days of collaborative modelling and experience analysis exercises.

Modelling: During the third day participants were given the freedom to use a model of their preference and the KET project benefitted from the creativity of the individuals.

Facilitation: During the third day two individuals facilitated the KET session. While the researcher added the experience of the method being used, the organisation leader had the experience of the subject being discussed.

On the data collected

Following the principles for data collection outlined in table 5.1 and limited by the necessary confidentiality issues, a small sample of the data collected during the collaboration with MoDInfra is included in appendix A, within the folder

MoDInfra / Original Data Collected /

The nature of the topics discussed during the KET sessions did not allow the voice-recording of the meetings. Documentation produced was recorded by keeping either the flip chart sheets produced or their digital image.

E-mail communication between the facilitator and individual members of the MoDInfra section was sustained during all stages of the process. Photographs of the room where the exercise was run were taken.

Conclusion

The key lessons learned from the application of CoMEx at MoDInfra are summarised in table 5.9 below:

Table 5.9. Key lessons learned from the application of CoMEx (v3) at MoDInfra

Stage	Key issues
Project preparation	The project emphasised the positive effect that official, institutional support may have in the implementation of the method
Knowledge elicitation and transfer sessions	<p>The project showed that the maximum number of meetings and the duration of the meetings are determined by the perception of the KET team or the practicalities of their implementation. Version 3 of CoMEx is flexible enough to allow as many meetings as the team considers necessary.</p> <p>It was observed that version 3 of CoMEx is not dependent on the researcher acting as a KET facilitator. A different facilitator could add his/her own perspective to the method if he/she is fully committed to achieving best results. Also, the method worked with more than one facilitator.</p>

After applying the KET method in manufacturing and academic environments, the collaboration with MoDInfra suggested that version 3 of CoMEx was stable and that it also worked within a project management organisation.

At this stage, the researcher considered that enough data had been collected and that it was appropriate to conduct the cross-case analysis of those data. No more field work was strictly required to the aims of addressing the research questions that had driven the data collection process.

5.3. Summary of the data collection process

After its initial design at GTM Ltd in 2007, the new approach to KET has been validated and CoMEx has been refined over a 20-month period. More than 40 knowledge-intensive workers from 3 organisations in different sectors have participated in the field work reported in this chapter.

The data collection process was driven by a number of factors that included the following:

1. The main research question driving this research.
2. The set of additional research questions that were outlined in chapter I.
3. A conceptual framework that included the main concepts to be studied and the relationships among them, presented in figure 5.1.

The structure of the data set collected during the implementation of each of the KET exercises in the field is presented in table 5.1. A section of the actual data collected is available in appendix A. Constrained by the need to protect the confidentiality of the organisations involved, the data in appendix A includes at least references to:

- Over 30 hours of voice recordings.
- Significant amount of notes taken as a result of direct observation.
- Presentations of the outcomes of the KET projects, made in different contexts.
- A significant number of documents reviewed in all the organisations involved.
- A large number of e-mails sent to and received from individual participants during all KET exercises.

During the application of CoMEx in the field, assessment and refinement of the method have been successfully interleaved. Thus, the field work has produced a reliable method for KET in organisations and the data that would enable its evaluation.

As described in section 5.2.1, the researcher was aware that combining CoMEx assessment with its refinement may have affected the conclusions that could be drawn from the data collected. However, the value of the contribution to the body of

knowledge in the KM field provided by this approach to conducting the field work outperforms the limitations it imposes to the evaluation of the method.

The following chapter will concentrate on the analysis of the data collected.

Chapter VI

ASSESSMENT OF THE NEW APPROACH TO KNOWLEDGE ELICITATION AND TRANSFER

Based on the research problems set during early stages of the research, a new approach to knowledge elicitation and transfer has been developed. Previous chapters have described the fundamentals of this new method and the sequence of what data were collected and how, during each implementation of the method in the field.

This chapter describes how these data were processed, condensed and displayed for the drawing and verification of conclusions that address the research problems.

6.1. Analytic strategy adopted

6.1.1. Complexities of the data analysis

The previous chapter described how a large amount of qualitative data was collected during the implementation of a multiple case study. This chapter will describe how the researcher used these data for the purpose of evaluating CoMEx.

The nature of the qualitative data collected mainly through observation, interviews and e-mail communication meant that an interpretivist approach to its analysis would be required.

Despite the value of qualitative data as a source of rich descriptions and explanations of processes, there are a number of well known difficulties associated to their analysis. These include the likelihood of data overload, particularly in a project like the one being reported in this dissertation, which collected more than 30 hours of voice recordings in four organisations over a period of three years. Associated with such volumes of qualitative data are the time demands of processing. Also challenging would be

providing evidence of the applicability of the new approach to KET in other organisations and by other individuals different from the researcher who implemented, assessed and refined it in the field. In general the researcher would have to seek in the data evidence of the credibility and quality of the conclusions and their utility for action, and do this by using methods of analysis that to this date are not well formulated.

Auerbach and Silverstein (2003) suggest that an essential step for a successful data analysis is to be able to define, during early stages of the of the data collection, the way such data would be analysed. This meant that the researcher had to face the challenges of the data analysis process as early as the field work started.

While Myers (2009, p.166) highlights that there is a “*tremendous variety of approaches*” to qualitative data analysis, Côté et al. (1993, p. 128) argue that such analysis remains a flexible process and there is no one correct way of doing it. Analysing case study evidence is especially difficult, Yin (2009, p.126) argues, because there is not a well defined technique to carry out such analysis.

Ritchie and Lewis (2003, p. 219) have concluded that making sense of the data collected is more dependent on the analyst and her or his conceptual thinking than on the method or tools used. However, these and other authors, such as Miles and Huberman (1994), Auerbach and Silverstein (2003), and Bryman and Bell (2007), agree on the importance of trying to achieve two main targets while carrying out qualitative data analysis. These are:

- Focusing on the most important aspects of the data collected.
- Transforming the data into something meaningful for the research and its audience.

6.1.2. Outline of the analytical process adopted

In order to achieve the two targets mentioned above, Yin (2009, p.128) suggests following a relatively straightforward process. It consists of identifying, for each research question, the evidence that addresses it; then drawing a conclusion based on the weight of that evidence and, finally, displaying that evidence in such a way that readers can check the validity of the conclusion. This process is a synthesis of a wider analytic strategy, previously defined by authors such as Miles and Huberman (1994) and Ritchie

and Lewis (2003). This research has adopted a process defined by those authors, which is based on the following principles:

1. Data reduction

A process of selecting, focusing, simplifying, abstracting, and transforming the data collected. These are essential steps that help making the data collected during the implementation of the multiple case study manageable and enable its understanding.

The original set of data collected during each application of CoMEx in the field included data that was relevant for the purpose of implementing the KET exercise and also data that was relevant for the purposes of evaluating CoMEx. After filtering the data set, every piece of data that was relevant for the evaluation of CoMEx was coded. In certain cases, such as interviews, the data were transcribed before codes were applied.

A description and part of the actual contents of the reduced and transcribed data set for every KET exercise can be found in appendix A under the folder

[Organisation /] Data reduction and transcriptions / [KET Exercise /]

A description and contents of the relevant data set for every KET exercise after codes were applied are included in appendix A under the folder

[Organisation /] First level coding / [KET Exercise /]

2. Data display

An organised, compressed assembly of information that permits conclusion drawing and action. Terms such as conceptual frameworks or conceptual indices are also used to refer to data display tools such as matrices, graphs, charts and network diagrams. Tables focusing on the most important aspects of the data collection will be used in this research. These have the potential to enable the reader to see what was happening during the implementation of each KET project in the multiple case study and also draw justified conclusions.

After being reduced, transcribed and coded, the data that were relevant for the evaluation of CoMEx were analysed and presented in a tabular form. For every

KET exercise in the field, the result of the data analysis is included in appendix A, within the folder

[Organisation /] Results of data analysis /

Given the relevance of this information for the understanding of the results of the data analysis, each of these tables has also been included either in the body of the thesis or in appendix B.

3. Conclusion drawing and verification

Once the data set has been reduced and relevant data have been presented in an organised manner, conclusions can be drawn. Conclusion drawing refers to the process of deciding what things mean by noting regularities, patterns, explanations, possible configurations, causal flows and propositions.

The results of the analysis of data collected from the application of CoMEx within each organisation were then used to generate theoretical constructs. These theoretical constructs were then grouped into conclusions.

Verification of conclusions seeks to validate the findings by revisiting the data collected looking to confirm the conclusions. In order to verify the conclusions, the researcher sought feedback from each of the organisations involved in the research.

Miles and Huberman (1994) and Yin (2009) also recommend seeking linkages between the qualitative and quantitative data collected whenever it is possible. Quantitative data can help in validating, interpreting, clarifying and illustrating the validity and value of the new approach to KET proposed by this research.

The process for data analysis described in this chapter is an interactive process by which data reduction leads to ideas on what should go into a data display; whilst the process of developing the displays may lead to the drawing of conclusions.

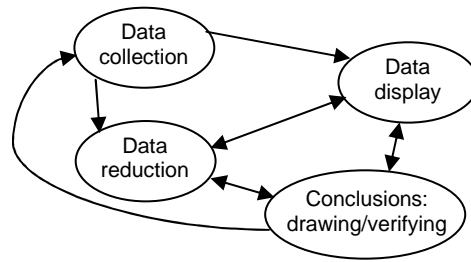


Figure 6.1. Components of data analysis – from Miles and Huberman (1994, p.12)

6.1.3. Quality of the findings derived from this approach to data analysis

Before the analysis of the data collected is reported this section will address the issue of how good the findings that will emerge from that process can actually be. There is a wide variety of views of what makes a good conclusion. These range from the epistemological position of authors such as Guba and Lincoln (1994), who focus on how the research findings fit into what is the accepted body of knowledge, to the practical position of Ritchie and Lewis (2003), who focus on the reliability and validity of the findings of the research. The researcher will adhere to the “critical realist” tradition described by Miles and Huberman (1994, p.277). This means that the quality of the findings of this research will be measured by analysing five main, somewhat overlapping, issues described by Miles and Huberman (1994). These are:

- The objectivity/confirmability of the qualitative work.

This is measured in relation to the extent to which the results are relatively neutral and reasonably free from unacknowledged researcher biases. The findings must not depend on the subjects involved or the conditions of the research.

The researcher has sought to describe explicitly and in detail in this dissertation the methods and procedures used for the collection and analysis of data. The sequence of what data were collected during each individual KET project and how these data were collected was described in previous chapters. All the data collected, regardless of its format, have been retained and most of these are

available in the appendices for reanalysis by others. This chapter describes how these data were processed, condensed and displayed for conclusion drawing.

All these issues are intended to make the findings of this research objective and confirmable so that it is possible for the work reported in this dissertation to be replicated.

- The reliability/dependability/auditability of the qualitative work.

This is measured by analysing whether the process followed to carry out the study has been consistent across the different organisations and individuals involved in the multiple case study.

The research problem and associated questions were made clear at the beginning of this dissertation. The researcher intended to study the problem of eliciting knowledge from experts and transferring such knowledge to other individuals and workgroups. The multiple case study and the related data collection and analysis processes were designed and applied congruently with the research questions. Data were collected across a range of appropriate settings, i.e. organisations for which the elicitation and transfer of specific pockets of knowledge was important. The findings of the applications of CoMEx show a meaningful parallelism across the different organisations involved. The researcher's dual role in the multiple case study as a researcher and KET facilitator has been made clear in the dissertation.

- The internal validity/credibility/authenticity of the qualitative work.

This is studied by asking whether the findings of the research make sense and whether they are credible to the people involved in the research and to the reader. The researcher will seek to demonstrate that he has “an authentic portrait” of the subject that has been studied.

As it has been previously outlined, the research problems were set during early stages of the research, and the research questions led the data collection process. There is significant evidence that the data was collected by applying the process for knowledge elicitation and transfer defined in chapter IV of this dissertation. As a result, the findings of the case study as reported in this chapter are coherent

with both the issues leading the research and the method defined to explore those issues.

Negative evidence that was collected during the multiple case study has also been considered. The dissertation has reported the ways such negative data, often related to particular implementations of CoMEx, has been handled by the researcher. The analysis of negative data during the implementation of the multiple case study usually resulted in a refinement of the KET method.

- The external validity/transferability/fittingness of the qualitative work

This issue is analysed by judging whether the conclusions of this research have any validity beyond the scope of the organisations and individuals involved in the case study. The research findings are expected to be transferable to other contexts and, to a certain extent, generalised.

Although identities of three out of the four organisations involved in the multiple case study have not been revealed in this dissertation, their characteristics have been described to an extent where a reasonable understanding of the KET projects reported is possible. The organisations involved form a diverse sample that includes manufacturing, research and project-based organisations, and as a consequence different types of knowledge have been targeted. This suggests that the application of CoMEx is likely to achieve reasonable levels of success in other organisations within sectors that at least include the ones represented in the multiple case study. A general cross-case analysis will be provided in this chapter as part of the data analysis. All of these seeks to provide the reader with the necessary tools to assess the potential transferability and appropriateness of the KET proposed for his or her own organisation.

- The utilisation/application/action orientation of the qualitative work

This is studied by exploring the benefits that this research brought to the organisations and individuals involved in the multiple case study. The work reported in this research will be “pragmatically valid” only if it leads those

decision-makers and other individuals that seek information on KET in this report to more intelligent action.

The findings of this research are intellectually and physically accessible to its potential users. At the time of writing this dissertation one of the organisations involved in the multiple case study is planning the implementation of CoMEx to retain the knowledge of two of its leaving experts. The researcher is intended to train a KET facilitator and supervise such an interesting project.

The actions taken by this research have had a multiple effect: they have helped the organisations involved to solve local, yet relevant problems in terms of sharing of expertise; they have produced a principled approach to knowledge elicitation and transfer; and they have enabled the collection of necessary data for the validation of the findings towards completion of the PhD research. CoMEx has been significantly documented as a result of the research and its definition has been included in chapter IV of this dissertation. This allows its usability by organisations while addressing similar knowledge-related problems.

6.1.4. Ethical issues considered

Qualitative data analysis is, regardless of the analytic strategy used, more than a technical matter. Any qualitative research is surrounded by a wide range of moral and ethical questions. Miles and Huberman (1994, p.289) conclude that there is not a well-formulated set of ethical guidelines that could be used by qualitative researchers across a range of disciplines. However, while conducting the multiple case study, analysing the data collected and reporting the findings the researcher has followed the guidelines provided by a set of ethical principles acknowledged in the literature on qualitative data analysis by authors such as Bryman and Bell (2007), Guillemin and Gillam (2004), Rossman and Rallis (2003) and Miles and Huberman (1994). These principles include:

1. Harm to participants, which entails a number of facets that range from physical harm to harm to career prospects or future employment.

This research has not carried out any action that could result in harm to the organisations or individuals involved. Each instance of the multiple case study was based on the sharing of their knowledge. Their participation in the KET exercises

took place in an environment free from any sources of physical or professional harm. As is discussed in this chapter, all participants enjoyed being part of the exercises and described these as a valuable contribution to their work.

2. Lack of informed consent, which means that prospective research participants should be given as much information as might be needed to make an informed decision about whether or not they wish to participate in the study. The notion of informed consent is very much linked to the invasion of privacy.

The researcher engaged in a written and verbal communication with each of the organisations involved in the research during the initiation stage of the corresponding projects, well before any action related to KET took place. The aim of that interaction was to give the organisation as much information as possible for them to make an informed decision about whether or not they wanted to participate in the study.

The organisations were informed of the importance of having individuals' full support. Although this was not fully addressed by the researcher in all cases, there is no evidence that suggests that individual participants were not fully aware of the nature of the project before they joined.

3. Deception, which occurs when researchers represent their research as something other than what it is. Deception is closely related to lack of honesty and lack of trust between both parties.

The researcher was honest with organisations and participants during the preparation and running of all the collaborations that the research involved. Every project within the multiple-case study was planned and executed on the basis of trust between the parties involved. Every organisation and individual participant was aware of the researcher's dual role as a postgraduate student at Cranfield University and a facilitator of their projects, and also knew that the collaboration was of benefit for both parties involved.

4. Worthiness of the project, or whether the study contributes to a knowledge domain.

Two main issues made this research project worthy. The first one was the lack of a successful, established mechanism for knowledge elicitation and transfer in

organisations. Through the field work conducted this research has made a significant contribution to the domain of Knowledge Management, in particular within the area of knowledge elicitation and transfer. The second issue was the evidence collected from the field to describe the value of this study for the four organisations and the individuals involved. As is analysed in this chapter, there is evidence to suggest that the application of CoMEx has had a positive effect in the work of the organisations and individuals involved.

5. Competency boundaries. This refers to whether the researcher was prepared to study, be supervised, trained, and if such help was available.

This study was prepared from its early stages and supervised throughout its development, particularly when collaboration with organisations was required. The researcher received significant training at Cranfield University and elsewhere. During the period where the major section of the field work was carried out the researcher was also involved in a KM initiative on a full time basis. The experience acquired in such a project also contributed significantly to the outcomes of the research.

6. Benefits, cost and reciprocity, in reference to whether each party to the study, i.e. organisations and the researcher, gained from having taken part; the resources organisations invested and the balance between gains for the researcher and the organisations and individuals involved.

Not only the researcher but each organisation involved in this study gained from having taken part in a KET exercise as part of the multiple case study. The researcher sought to maximise the value of the resources that the four organisations invested in the corresponding exercises, such as the time of their experts and the cost of organising and running the exercises, particularly high in the MoDInfra exercise. In an effort to provide organisations with the maximum benefits the researcher produced on occasion deliverables that did not directly benefit his research, such as a fault diagnosis system that would enable GTM Ltd to prove the validity of the concept developed during the collaboration.

However, it can be argued that there was a good balance between benefits of this research for the researcher and for the organisations and individuals involved.

7. Privacy, confidentiality and anonymity, which refer, respectively, to the extent to which the study intrudes, or come closer to people than they want; to the way that data collected and any related information will be guarded; and to the extent to which the individuals and organisations studied are identifiable from the research report.

The fact that the research reported in this dissertation was concerned with the elicitation and sharing of expertise meant that there was no need to infringe the privacy of individuals or organisations involved. Data collected has been presented in such a way that identification of the source, be it an individual or an organisation, is not possible.

As it has been previously discussed, the collaborations were established on the basis of mutual trust between the parties involved. This meant that no confidentiality agreement was signed during any of the projects, even when such an issue was discussed with the organisations involved. However, the researcher shared with each organisation the relevant sections of this thesis even when their identities had not been revealed in the document. E-mails were received from GTM Ltd, PowerTech UK Ltd and MoDInfra to grant approval for publication of the thesis. These e-mails are included in appendix A of this dissertation, within the folder

Permission to publish /

With regard to Cranfield University, the researcher understood that the lack of confidential issues in the data collected and the supervisor's approval for submission of the thesis would also act as a permission to publish and no further approval was sought.

The remainder of this chapter will focus on the analysis of the data collected. The ethical issues mentioned in this section will be revisited after the data has been analysed in order to assess the extent to which this research has remained ethically conscious.

6.2. The process of reducing the data collected

6.2.1. Introduction

Throughout the field work, data was collected in the form of handwritten or typed field notes, e-mail exchanges and recordings of interviews and knowledge elicitation and transfer meetings that took place in the organisations involved in the multiple case study.

The researcher included most of the field notes taken throughout the research in a single notebook. Notes on such a notebook are on occasions sketchy, fairly illegible and contain private abbreviations. The example in figure 6.2 has been extracted from the researcher's notebook and represents a valuable piece of data collected during a meeting at GTM Ltd on Monday 11 June 2007. The researcher summarised in a few words the main concerns of the manager involved in the meeting, and these ideas were essential in the running of the KET sessions at GTM.

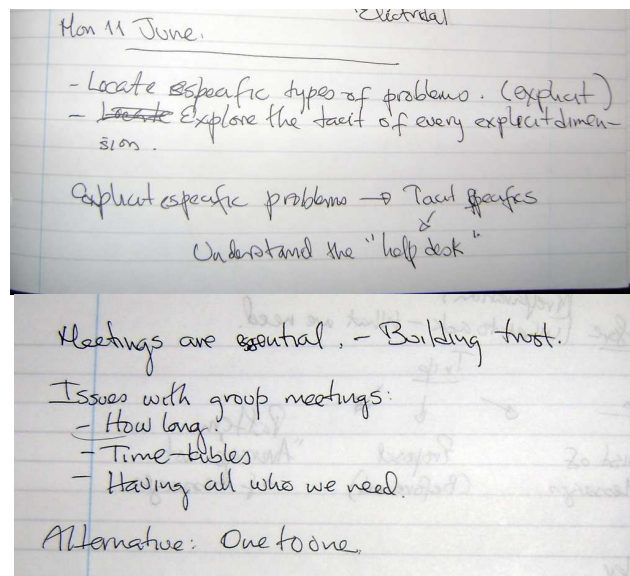


Figure 6.2. Excerpt from the data collected in the form of researcher's notes

The researcher also collected over the course of the field work more than 30 hours of direct recordings of field events such as interviews and KET meetings. While all the recordings added value to the research and must therefore be processed, not every piece

of data in this format was relevant. For example, 25 minutes of explanations of how a gas turbine recovers from a transient pressure dip, provided by a Help Desk expert at GTM Ltd during one of the KET sessions, becomes valuable knowledge for the organisation. However, the details provided by the expert do not provide a significant input for the purpose of assessing the validity of CoMEx.

E-mail exchanges between the researcher and individuals who participated in the multiple case study also provided a significant input to the data set to be analysed. Some of those e-mails contained information that was only relevant at the time that they were sent or received, e.g. those e-mails related to times and venues of KET sessions. However, the largest number of e-mails included valuable information for the purpose of evaluating CoMEx and therefore these e-mails required analysis.

Figure 6.3 includes sections of an e-mail sent on 15 October 2009 by an individual who participated in the KET exercise at MoDInfra. This e-mail added significantly to the analysis reported in this chapter as it includes the perception of a participant in relation to the value of CoMEx for his organisation, on how CoMEx compares to other methods he had experienced in the past, the importance of the facilitation techniques for the outputs of the exercise and even recommended areas for improvement. However, other information contained in the e-mail was not relevant and therefore decisions would have to be made by the researcher in order to transform the e-mail into a reduced set of relevant data.

1.2. Do you see any scope for change in the model and the concepts included? If so, could you mention the areas where it could be changed?

CoMEx follows a solid sequence of question, analyse, act: intuitively it seems to follow the same broad logic as other models, e.g. antithesis/thesis or the well used/abused OODA loop (Boyd cycle – Observe, Orientate, Decide, Act). Either way it does seem to provide a sound framework for thinking. I have become used to the OU MBA approach to change which involves a more proactive approach to the creative thinking and people engagement inherent in such models. I think that the model could be enhanced in its application if a more systematic approach were taken to engaging those involved and in mounting deliberate ‘excursions’ from accepted practice or ‘the norm’.

2.1. Has this exercise affected your conception of the [MoDIinfra] Programme and the [MoDIinfra] Section? If so, could you briefly explain how?

I think it has reinforced my perception. The model led us down a route of ‘question/analyse’, prepare and then deliver which has fitted the preparatory period well. It also encouraged us to have a valuable and useful look at what success might be and provided us with a conceptual view of that. However, fundamentally it has involved all in an open discussion, exchange of ideas and knowledge transfer. In that sense it has been very valuable and the presence of interpretive facilitation was a valuable extra factor in helping the team building that is essential at this early stage of a programme.

2.2. Are there any ways in which the resulting concepts and model could be used?

I find this quite difficult to answer directly as in many respects the CoMEx philosophy is now embedded within the team’s identity. The team is, therefore, the model works! I think that I will certainly use the tangible outputs as a frame of reference to measure development progress and also the summary of ‘what success means’ as a check against what we plan to deliver. Sadly I will not be around for the end game and can only pass on the models to my successor.

3.1. Do the concepts and model developed tie in with your experience within this or related programmes?

I have seen several programmes start off without such a simple and flexible framework for thinking and without any real idea of the need for knowledge transfer at the start. I would, therefore, suggest that it has put us ahead of the game. I have used in the past the Nonaka and Tagueuchi (sp?) model (see below and can see strong parallels with CoMEx. Both encourage knowledge transfer/sharing, perhaps the CoMEx could be developed to reflect the cyclic nature of the SECI model?

4.1. Do you have any additional comments regarding the exercise and its outcomes, or any suggestions looking forward to the next exercise in October? Very grateful for your support and participation. The [MoDIinfra] Section is now on its feet and following the 2 sessions now in full swing and beginning to leave me behind! Must be working well...

Figure 6.3. An example of data to be analysed. Sections of an e-mail received from a CoMEx participant during the post-process review

In all cases the data collected took the form of *words* and had to be transformed and refined into a text that was clear to the researcher at the time of its analysis and is now clear to the reader. Field notes were converted into “write-ups” that could be read, edited, coded and analysed. A similar process was carried out with e-mail communication. As with recordings, the researcher listened to the recordings, made notes to highlight, for example, the proportion of experts’ contribution to a KET meeting, selected excerpts that were relevant for the purposes of the research and made judgements or ratings where appropriate. In many cases sections of the recording were transcribed into text.

The resulting data set, containing for every organisation a sample of those pieces of data that are relevant for the evaluation of CoME_x, is included in appendix A under the folder

[Organisation /] Data reduction and transcriptions / [KET Exercise /]

This process of considering and implementing the analytical choices of the researcher in terms of decisions such as which data chunks to code and which to pull out, which patterns best summarise a number of chunks and which story to tell, is referred to by Miles and Huberman (1994) as data reduction. To achieve the aim of reducing the data collected, the researcher followed two main steps:

1. Coding the data

Review the set of field notes after these were transcribed and synthesised, and dissect them meaningfully, while keeping the relation between the parts intact (Miles and Huberman, 1994). This was achieved in two levels:

- a. Summarising segments of data by assigning units of meaning to the data collected using tags or labels.
- b. Grouping those summaries into a smaller number of sets, themes or constructs by looking for patterns.

2. Developing theories using the patterns previously identified.

A theory in this research is considered to be “a description of the pattern found in the data” (Auerbach and Silverstein, 2003). The researcher focused on developing

theories that were relevant for the factors that drove the data collection, outlined in section 6.1.1.

The remainder of this section focuses on describing each of the steps followed during the analysis of the data collected while implementing the multiple case study.

6.2.2. First-level coding

Authors such as Bryman and Bell (2007, p.593), Myers (2009, p.167) and Auerbach and Silverstein (2003, p.33) describe coding as the use of words to assign meaning to a piece of data gathered, be it a sentence, a paragraph or an interview.

Miles and Huberman (1994, p.56) mention that codes usually are attached to ‘chunks’ of varying size –words, phrases, sentences, or whole paragraphs, connected or unconnected to a specific setting.

Following the views of Berg (2004, p.274), the researcher understood coding as the process of grouping words together into conceptual clusters representing ideas that constitute variables in at least one of following:

- a. The research hypothesis.
- b. The research questions (RQ) and related conceptual framework.
- c. The literature review, where the limitations of existing approaches to knowledge elicitation and transfer are outlined.

A provisional set of codes was created during early stages of the data analysis process and expanded as such a process progressed. The resulting set of codes is described in tables 6.1 and 6.2.

In table 6.1 the first column includes a short descriptive label for the general categories and the individual codes and the second column shows the codes. The third column includes the source from which the issue described by the code (detailed in table 6.2) derives.

Table 6.1. The list of codes used in the research

Category/code	Code	Source
<u>Category</u> : Limitations of KET techniques	Lim	Literature review, RQ, Hypothesis, Conceptual Framework
Lim: Demands	Lim-D	Literature review, RQ, Hypothesis, Conceptual Framework
Lim: Experts	Lim-P	Literature review, RQ, Hypothesis, Conceptual Framework
Lim: Motivation	Lim-M	Literature review, RQ, Hypothesis, Conceptual Framework
<u>Category</u> : Group dynamics	Grp	Literature review, RQ1, Hypothesis, Conceptual Framework
Grp: Variables	Grp-V	Literature review, RQ1, Hypothesis, Conceptual Framework
Grp: Facilitation	Grp-F	Literature review, RQ1, Hypothesis, Conceptual Framework
Grp: Communication	Grp-C	Literature review, RQ, Hypothesis, Conceptual Framework
<u>Category</u> : The KET method	Mtd	Literature review, Hypothesis, Conceptual Framework
Mtd: Outcomes	Mtd-O	RQ, Hypothesis, Conceptual Framework
Mtd: Model	Mtd-M	Literature review, RQ2, Conceptual Framework
Mtd: Participants	Mtd-P	Literature review, RQ3, Conceptual Framework
Mtd: Knowledge	Mtd-K	Literature review, RQ4, Conceptual Framework
Mtd: Technologies	Mtd-Tec	Literature review, RQ5, Conceptual Framework
<u>Category</u> : Evaluation of success of KET	Eval	Literature review, RQ6, Conceptual Framework

The following table provides a definition of the codes shown in table 6.1:

Table 6.2. Definition of the codes used in the data analysis

Codes related to the limitations of KET techniques (Lim): Used to group issues that hinder the success of existing approaches to KET as reported in the relevant literature, and the way CoMEx addresses these.	
Code	Describes data that is relevant to understand...
Lim: Demands	the effects that the demands of the application of CoMEx may have in the elicitation and transfer of knowledge.
Lim: Experts	the effects that the ability of experts to contribute their knowledge whilst in the exercise may have in the success of the KET process.
Lim: Motivation	the effects that motivational issues related to the elicitation of the knowledge from experts and to the acquisition and application of that knowledge by individuals and workgroups may have in the outputs of the KET process.
Codes related to the topic of group dynamics – Grp: Used to describe issues that show the extent to which CoMEx takes into account the lessons learned from the field of group dynamics in an attempt to achieve better results in terms of KET.	
Code	Describes data that is relevant to understand...
Grp: Variables	whether CoMEx considers the issues that influence individuals' comfort zones, such as intrapersonal, interpersonal and environmental variables.
Grp: Facilitation	whether a KET facilitator or moderator of a CoMEx exercise can become an enabler of learning processes.
Grp: Communication	whether a process of communication of ideas and knowledge where contributions are not restricted to specific group members can take place during the implementation of CoMEx.
Codes related to the KET method – Mtd: Used to describe issues that are relevant to understand the extent to which specific characteristics of CoMEx help in making it a successful KET method.	
Code	Describes data that is relevant to understand...
Mtd: Outcomes	the outcomes that running a KET exercise using CoMEx brought to the organisation and the individuals involved.
Mtd: Modelling	whether models and modelling have the potential to support the KET processes.
Mtd: Participants	whether the method proposed by CoMEx to identify experts and practitioners who will be involved in the KET process helps it achieving its aim.
Mtd: Knowledge	whether or not different types of knowledge can be effectively elicited from experts and transferred to other individuals and groups using CoMEx.
Mtd: Technologies	the role of technologies in the KET process when CoMEx is applied.
Eval	how KET processes can be evaluated, based on the experience of applying CoMEx.

Once the list of codes had been defined, the researcher analysed all the data collected, i.e. field notes, e-mail communication, transcripts of the interviews and recordings of KET sessions. For every relevant piece of data the codes described in tables 6.1 and 6.2 were embedded in the original text, where such texts existed, or in notes related to the data for those cases in which these had not been fully transcribed (e.g. in recordings of KET sessions). An example of identifying relevant text within a section of the e-mail previously presented in figure 6.3 and embedding codes in it (in bold following the relevant text) is shown in figure 6.4.

I think [the application of CoMEx] has reinforced my perception [of the knowledge domain] **[Mtd:Outcomes]**. The model led us down a route of 'question/analyse', prepare and then deliver which has fitted the preparatory period well. It also encouraged us to have a valuable and useful look at what success might be **[Mtd:Knowledge]** and provided us with a conceptual view of that **[Mtd:Outcomes]**. However, fundamentally it has involved all in an open discussion **[Grp:Communication]**, exchange of ideas and knowledge transfer **[Mtd:Outcomes]** **[Mtd:Modelling]**. In that sense it has been very valuable and the presence of interpretive facilitation was a valuable extra factor **[Grp:Facilitation]** in helping the team building that is essential at this early stage of a programme.

2.2. Are there any ways in which the resulting concepts and model could be used?

I find this quite difficult to answer directly as in many respects the CoMEx philosophy is now embedded within the team's identity **[Mtd:Outcomes]**. The team is, therefore, the model works! **[Mtd:Outcomes]** **[Mtd:Participants]**. I think that I will certainly use the tangible outputs as a frame of reference to measure development progress **[Mtd:Outcomes]** and also the summary of 'what success means' as a check against what we plan to deliver **[Mtd:Outcomes]**.

The [MoDInfra] Section is now on its feet and following the 2 sessions now in full swing and beginning to leave me behind! **[Mtd:Outcomes]** **[Mtd:Participants]**. Must be working well...

Figure 6.4. An example of identifying relevant data from an e-mail and assigning codes to these data

Every individual document considered relevant for the evaluation of CoMEx was coded. A description and sections of the contents of the relevant data set for every KET exercise after codes were applied are included in appendix A under the folder

[Organisation /] First level coding / [KET Exercise /]

The reduction and structuring of the data set facilitated its analysis when searching for patterns, which was the focus of the next phase of the process reported in this chapter.

6.2.3. Second-level or pattern coding

The first-level coding described in section 6.2.2 helped the researcher summarise segments of data contained within specific documents produced during the data collection process. However, at this stage it was necessary to group those summaries into a smaller number of ideas or themes that were representative of the perception of more than one individual. Auerbach and Silverstein (2003) understand a theme to be an implicit topic that organises a group of repeating ideas. According to Miles and Huberman (1994), pattern coding helps the researcher understand the patterns and recurrences, which Auerbach and Silverstein (2003) refer to as ‘repeating ideas’.

In order to identify those patterns, the researcher reduced the data that resulted from the first level coding using a smaller number of concepts that could be mentally stored and readily retrieved. These concepts, included in figure 6.5, synthesise the sets of concepts that were originally defined in tables 6.1 and 6.2 and used for the first level coding.

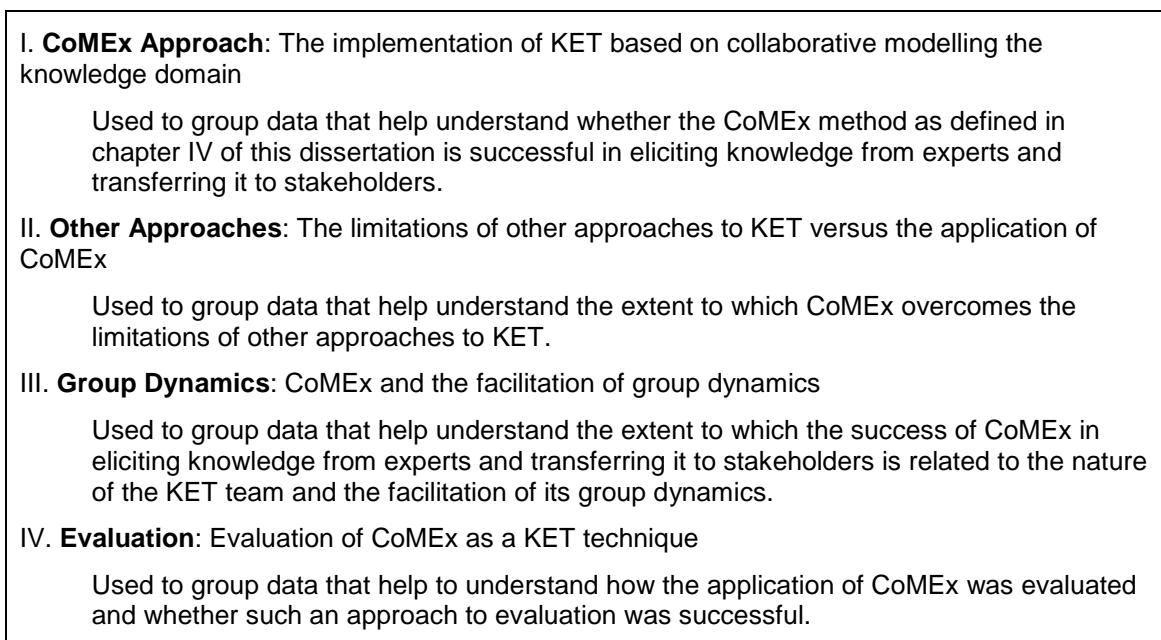


Figure 6.5. The concepts and ideas that were used during the second level coding of the data collected throughout the multiple case study

Data reduction in the second level coding was based in the search for recurring facts in the implementation of CoMEx in different organisations, or recurring phrases and common threads in interviews, e-mails and other data that had been already coded. Such repeating ideas and themes were extracted and displayed in a number of tables.

The rationale behind displaying the data using tables is related to the limitations of purely text-based evidence. Tables act as focused display that will permit a viewing, in the same location, of a full data set derived from every single case study. Tables helped the researcher to draw conclusions that answer the research questions, and are intended to help the reader to better understand the origins of such conclusions. The use of tables is supported by the researcher's experience in using different visual representation schemes as an aid to conveying knowledge that could otherwise be difficult to understand.

The second-level analysis of the data collected during the application of CoMEx at PowerTech UK Ltd is included in table 6.3. A similar analysis for GTM Ltd, Cranfield University and MoDInfra is included in appendix B.

Table 6.3. Key ideas and themes from the series of KET exercises at PowerTech UK Ltd

<p>I. CoMEx approach: The implementation of the KET exercise based on collaborative modelling the process of handling customer queries</p>	
<p>A. Outcomes of the application of CoMEx</p>	<p>The outcomes identified from the data collected can be grouped into four main categories:</p> <ol style="list-style-type: none"> 1. Learning by experts: <p>All experts mentioned that CoMEx focused their minds on the processes that they normally go through, and also that it made them consider how they operate and what information resources they need and use. Examples of this include:</p> <p><i>“I had forgotten all the processes we have, so the discussions helped as a reminder of them all”.</i></p> <p><i>“It made me consider the way we operate & also ensure that adequate documentation is generated”.</i></p> 2. Learning by stakeholders: <p>All stakeholders mentioned that they managed to know more ways of handling customer queries and also more information resources. Examples of this include:</p> <p><i>“I expect some improvement in my work”</i></p> <p><i>“The discussions highlighted some other ways of acquiring information that could help me in the future”</i></p> <p>The KM team understood the key issues that were used to define the focus of its work during the following three years. These included the Service engineers’ way of working and their knowledge requirements.</p> 3. New explicit resources became available: <p>Several models were produced capturing processes and KM issues relevant to Service engineers at PowerTech UK Ltd. These were in use by the KM team at the time of writing this dissertation.</p> <p>More than three hours of discussion of topics that are key to the success of the company were recorded, where experts’ contribution accounts for more than 80% of the time.</p> 4. Communities of interests: <p>Some stakeholders found that knowledge sharing communities were in place in other PowerTech units using internal facilities such as Lotus Notes Teamrooms. As a result they engaged in collaboration with these virtual communities.</p>

Table 6.3. Key ideas and themes from the series of KET exercises at PowerTech UK Ltd

B. Modelling	<p>Participants argued that the models and the explanations during their development helped understand the process of dealing with customer queries and revealed new sources of information available.</p> <p><i>“The process had a good effect in my understanding and it would help if we put more people into this process”.</i></p> <p><i>“After the model [was developed] everything was made clear and everyone seemed to be on the same page”</i></p>
C. Participants	<p>The list of potential participants were provided by the managers of the Service department and Innovation department according to the following principles:</p> <ol style="list-style-type: none"> 1. Experts were Service engineers with significant experience in dealing with customer queries, who had been with PowerTech for 12 years as an average. They were chosen from a list provided by PowerTech UK Ltd middle management. 2. Stakeholders fell into two categories: Junior engineers that needed training and familiarisation with PowerTech ways of working; and members of the KM team who needed familiarisation with the company and also an improved understanding of the areas that required the attention of the KM team.
D. Type of knowledge	<p>Knowledge relating to different aspects of the organisation's activities was successfully elicited and transferred using CoMEx. These are:</p> <ol style="list-style-type: none"> 1. Process knowledge, related to dealing with customer queries effectively and finding the knowledge needed to achieve that aim. 2. Knowledge about information requirements of Service engineers at work.
E. Technologies	<p>Evidence shows that Information and Communication Technologies were only used by the KET facilitator for the purposes of organising the exercises and requesting feedback from participants.</p>
<p>II. Other approaches: The limitations of other approaches to KET versus the application of CoMEx</p>	
A. Demands from participants.	<p>KET exercises at PowerTech UK Ltd only required from participants their response to an initial interview, their presence in the KET sessions and their response to a final questionnaire by e-mail at the time of their convenience.</p>

Table 6.3. Key ideas and themes from the series of KET exercises at PowerTech UK Ltd

<p>B. Experts.</p>	<p>Notes taken by the researcher during and after the KET sessions show that:</p> <ol style="list-style-type: none"> 1. The KET sessions took place in a relaxed, informal environment that helped experts to contribute their knowledge however they found it easier to do, e.g. through the use of examples, comparing the limitations of their individual approaches to handling customer queries, etc. <p>An example of this is the following comment from an expert:</p> <p><i>“It was a very relaxing environment; no pressure; nice questions”</i></p> <ol style="list-style-type: none"> 2. There is no evidence that suggests that any of the experts found it difficult to contribute their views on the topics discussed.
<p>C. Motivation</p>	<p>Data collected show that experts and stakeholders were motivated to actively participate in the exercises for different reasons:</p> <ol style="list-style-type: none"> 1. Experts: The KET facilitator was a member of the KM team and requested their views on the issues that they needed help with. Service engineers rightly felt that their contribution would be made worthwhile by receiving support in the ways they deal with customer queries. The following comments suggest that they were motivated to contribute their knowledge: <p><i>“It is good to have this kind of discussions so that we can learn things that are important for the company, and include people from other departments”</i></p> <p><i>“I think it was very fruitful”</i></p> <ol style="list-style-type: none"> 2. Stakeholders: In addition to the topic mentioned above, junior engineers were motivated by the fact that they would be discussing their problems with members of the reputable Marine and Offshore Service team, and they would be able to voice their knowledge-related problems to the KM team in the search of their support and guidance. The following comments have been taken as an example: <p><i>“The discussions highlighted some other ways of acquiring information that could help me in the future”</i></p> <p><i>“Seems to be a very good model [of the process], may be it needs proper document/template”</i></p>

Table 6.3. Key ideas and themes from the series of KET exercises at PowerTech UK Ltd

III. Group dynamics: CoMEx and the facilitation of group dynamics	
A. Variables affecting individuals' comfort zones	<p>Evidence was collected in the form of photographs to show that the researcher sought to consider intrapersonal, interpersonal or environmental variables when organising the exercises.</p> <p>There is no evidence in the data collected that suggests that intrapersonal, interpersonal or environmental variables had a negative effect in the success of any of the KET exercises at PowerTech UK Ltd.</p>
B. The role of the facilitator: An enabler of learning processes through an active control of the group dynamics, as opposed to a knowledge engineer or a domain expert.	<p>Data collected using different means highlights the following facts related to the facilitation of KET exercises at PowerTech UK Ltd:</p> <ol style="list-style-type: none"> 1. During the running of a KET exercise by a facilitator different from the researcher the following was observed: <ol style="list-style-type: none"> a. A reasonable understanding of the principles of CoMEx was essential for its facilitation. b. The lack of commitment to run all the CoMEx stages had a negative effect in the method achieving its aims. c. Limited application of basic facilitation techniques such as questioning had a significant effect in the success of the KET sessions. d. Despite the difficulties experienced during the running of that particular exercise, feedback received from all participants was positive and did not vary significantly from that received during other KET at PowerTech UK Ltd. 2. The running of the other four KET exercises by the researcher as a facilitator reinforced the validity of the issues a to c above.
C. Communication	<p>The observation, recordings and notes taken during the KET sessions show that participation was not restricted to experts' contributions in any of the five PowerTech exercises. Stakeholders contributed actively to the debates, even when it was only to raise questions and concerns in the search for experts' answers and support.</p>

Table 6.3. Key ideas and themes from the series of KET exercises at PowerTech UK Ltd

IV. Evaluation: Evaluation of CoMEx as a KET technique

KET exercises at PowerTech were evaluated in two ways:

1. Immediately after the exercise by asking participants
 - a. Whether the sessions had had an effect in their understanding of the domain.
 - b. Whether the meetings could have been run in a different way. Some suggestions for improvements were made, though comments were generally positive and ranged from describing the exercise as “very fruitful” to “just about right”
2. Six months later
 - a. By asking participants whether CoMEx had had an effect in the way they deal with issues that they consider critical for the success of their work.
 - b. By analysing the value of the outcomes of CoMEx for the work carried out by the KM team.

The learning from the CoMEx exercise guided the work of the team and presentations given to management during the following year. At the time of writing this dissertation the models were being used as a starting point of the assessment of success of the work that has been completed by the KM team.

Once relevant themes and recurring ideas for each individual case had been extracted, the analysis moved on to analyse those patterns that were valid across all the cases in the multiple case study. This process was based in the same codes that had been used for the second level coding, presented in table 6.3.

Table 6.4 contains a compilation of the main ideas and themes that resulted from a cross case analysis of the data collected, based on the concepts included in table 6.3.

Table 6.4. Cross-case analysis: Key ideas and themes

I. CoMEx approach: The implementation of the KET exercise based on collaborative modelling the process of handling customer queries	
A. Outcomes of the applications of CoMEx	<p>CoMEx successfully involved all members of the KET teams, regardless of their levels of expertise and particularly those at PowerTech UK Ltd and MoDInfra in an exchange of ideas and KET.</p> <p>In some cases (e.g. GTM, MoDInfra) the application of CoMEx produced models that are useful for the organisations where they were developed.</p> <p>The recordings of the KET sessions became a new source of explicit knowledge that is now available for reference.</p> <p>The applications of CoMEx contributed to the development of new or existing communities within the organisations involved. In particular, in the KET exercise at MoDInfra a team was built as a result of the implementation of CoMEx.</p>
B. Modelling	<p>The development of models helped in questioning and analysing the knowledge domain, which led to discussion and learning.</p> <p>Modelling helped in focusing all team members in the same topic and working toward achieving a common view.</p> <p>Most participants argued that modelling encouraged them to look at the issues discussed from a wider perspective.</p>
C. Participants	<p>Participants were in all cases selected by individuals within the organisation who knew where the pockets of expertise existed and where they were required.</p>
D. Type of knowledge	<p>Knowledge relating to different aspects of the organisation's activities was successfully elicited and transferred using CoMEx. These included:</p> <p>Process knowledge.</p> <p>Product knowledge.</p> <p>Project- and programme-related knowledge.</p> <p>Knowledge about individuals.</p>

Table 6.4. Cross-case analysis: Key ideas and themes

E. Technologies	Information and Communication Technologies were only used by the KET facilitator for the purposes of organising the exercises and requesting feedback from participants.
II. Other approaches: The limitations of other approaches to KET versus the application of CoMEx	
A. Demands from participants.	The implementations of CoMEx only required from participants their response to an initial questionnaire, their participation in KET sessions and their response to a final questionnaire. There is no evidence to suggest that these demands had a negative effect in the elicitation and transfer of knowledge.
B. Experts.	During early stages of CoMEx one of the exercises failed to allow all experts to contribute their knowledge during the KET session. Once the root cause was identified and addressed no evidence was collected that suggested that any of the experts found it difficult to contribute their views to the exercises being run.
C. Motivation	Participants in all exercises seemed motivated to express their views and contribute to the analysis of the knowledge domain. However, although motivated, some of the participants in one exercise found it difficult to contribute to the debate during a KET session. Once the root cause was identified and addressed no evidence was collected that suggested that participants in any other exercise had difficulties to participate.
III. Group dynamics: CoMEx and the facilitation of group dynamics	
A. Variables affecting individuals' comfort zones	Some of the issues affecting individuals' comfort zones had a negative effect in the success of CoMEx during an application of an early version of the method. The method was revised to address these issues by considering environmental variables before it was applied in subsequent KET exercises at PowerTech UK Ltd and MODInfra.
B. The role of the facilitator	Three different models of facilitation were experienced in the field: single facilitation by the researcher (6 cases), single facilitation by another individual (2 cases) and joint facilitation by a researcher and an individual (1 case). Only one of those models, i.e. single facilitation by another individual, did not achieve the same levels of knowledge elicitation and transfer as the other two models, as perceived by the researcher. Although participants' feedback did not reflect such a difference, the reasons related to facilitation were explored by the researcher.

Table 6.4. Cross-case analysis: Key ideas and themes

C. Communication	The analysis of the recording of a KET session during one of the KET exercises during early stages of the development of CoMEx showed that contributions were restricted to a limited number of participants. The root causes were identified and addressed and there is evidence that shows that in all subsequent applications of CoMEx all members made a significant contribution to the knowledge exchange.
IV. Evaluation: Evaluation of CoMEx as a KET technique CoMEx was evaluated in most cases by asking participants, some time after the KET exercise, their perception of the effect that their participation had in their achievement of what they considered the critical success factors of their work.	

6.2.4. Theoretical constructs

The data collected had been, at this stage, significantly summarised to a set of relevant patterns that emerged across the multiple case study. The researcher then moved one step further in the analysis by trying to generalise these findings. This was achieved by developing a series of theoretical constructs based on relevant patterns previously identified.

According to Auerbach and Silverstein (2003, p.39), a theoretical construct is a grouping of themes and ideas into larger, more abstract ideas consistent with the theoretical framework of the research. A theoretical construct can take the form of a sentence, a paragraph or a few pages. Writing theoretical constructs helps in moving from empirical data to a conceptual level, according to Miles and Huberman (1994).

A number of theoretical constructs were built from the data analysis carried out in this section. The results of the cross-case data analysis as presented in table 6.4 became essential in justifying the building of theory from the data collected. Using as an example the value of models as an additional output of the implementation of CoMEx, table 6.5 shows the process of building a theoretical construct using the data collected across the multiple case study:

Table 6.5. Building a theoretical construct: the models resulting from the implementation of CoMEx

Organisation	Results of the data analysis	Theoretical construct
GTM Ltd	The Bayesian network developed became an important tool for the Help Desk department. It could be used to help junior engineers in the field while dealing with customer queries. It could also be used to produce a fault diagnosis system that would save engineers' time by helping customers deal with basic problems in their gas turbines.	In addition to the elicitation and transfer of knowledge, running a CoMEx exercise is likely to bring other benefits to an organisation, including models of different aspects of the knowledge domain. Such models may become an explicit source of knowledge for reference by members of the organisation.
Cranfield University	<p>Four different models of the PhD research process were developed.</p> <p>Most stakeholders argued that the model they helped develop was a very useful tool and the first of its kind ever available to them.</p> <p>Some stakeholders use the model they helped develop to regularly assess the progress of their PhD research.</p> <p>Most experts recommend expanding these models to cover more issues and use the results of this process available for training of new PhD research students.</p>	
PowerTech UK Ltd	The 8 models of the process of dealing with customer queries and the related knowledge needs of Service engineers became the fundamentals of the last stage of a major KM initiative involving PowerTech and two UK Universities. The KM project will use the models to measure and communicate its success to PowerTech Senior Management.	
MoDInfra	The models produced have been included in the documentation of the MoDInfra Programme to facilitate its communication with all the programme stakeholders.	

Following a process similar to the one outlined in table 6.5 the following theoretical constructs (TC) were built:

TC-1. In the conditions of the organisations involved in this research, face-to-face, facilitated and collaborative modelling domain knowledge is a valid approach to KET.

TC-2. CoMEx is a valid implementation of a knowledge elicitation and transfer approach which is based on face-to-face, facilitated and collaborative modelling of the knowledge domain.

TC-3. In addition to the elicitation and transfer of knowledge, running a CoMEx exercise has the potential to bring other benefits to an organisation, including the following:

1. Outcomes which may become an explicit source of knowledge for reference by members of the organisation. The following were identified during the field work:
 - a. Models of different aspects of the knowledge domain.
 - b. Recordings of discussions held during the KET sessions.
2. The development of new and existing communities driven by the interests of some of the project participants in the continuity of the knowledge exchange.

TC-4. KET projects are more likely to be successful if they target specific individuals/workgroups and have a clearly defined focus. The organisation has an important role to play in the selection of participants and the knowledge domain on the basis of its own knowledge needs.

TC-5. CoMEx has been perceived as a successful method to be used for the elicitation and transfer of knowledge relating to different aspects of the organisation's activities. In the particular case of the organisations involved in the field work, four different areas were addressed. These included:

1. Process-related knowledge.
2. Product-related knowledge.

3. Project- and programme-related knowledge.
 4. Knowledge about individuals' skills and abilities.
- TC-6. Knowledge elicitation and transfer can be successfully implemented without relying on the use of information and communication technologies.
- TC-7. Based on the experience of the organisations involved in the multiple case study there is no evidence that suggests that the demands of implementing a CoMEx exercise have a negative effect in the achievement of its aims.
- Furthermore, data collected suggests that the organisations placed more emphasis on the benefits of their involvement than its cost.
- TC-8. On the basis of the data collected, individuals involved in knowledge elicitation and transfer using CoMEx feel motivated to contribute their knowledge and learn from other participants. CoMEx allows for a communication and adoption of ideas to take place.
- TC-9. A KET facilitator or moderator plays a major role in the success of a KET exercise based on the implementation of CoMEx. The role of a KET facilitator is one of co-ordinating and supporting the process by which experts and stakeholders share knowledge on a face-to-face basis.
- TC-10. The success of CoMEx as a KET technique can be assessed by exploring the alignment of its outcomes with the critical success factors of the organisation as perceived by the organisation.

6.3. The drawing and verification of conclusions

At this stage the evidence collected in order to answer the research questions has been substantially summarised and basic theory, consistent with the theoretical framework of the research, has been built. This work has paved the way for the drawing and verification of the conclusions of the data analysis.

6.3.1. Drawing the conclusions

Dealing with the additional research questions

The theoretical constructs built in section 6.2.4 became essential tools in the process of drawing the conclusions of the multiple case study. Many of the constructs represented in themselves part of the answer to the secondary research questions that led this research, which were outlined in chapter I as:

RQ-1. How can knowledge elicitation and transfer processes benefit from the lessons learned in other areas involving facilitated group collaboration techniques?

RQ-2. What do the concepts of knowledge elicitation and knowledge transfer mean and to what extent are they related to concepts such as learning?

RQ-3. How can models and the modelling process support the knowledge elicitation and transfer processes?

RQ-4. How can experts and practitioners who will be involved in knowledge elicitation and transfer processes be identified?

RQ-5. What types of knowledge can be effectively elicited from experts and transferred to other individuals and groups within the organisation?

RQ-6. What is the role of technologies in knowledge elicitation and transfer processes?

RQ-7. How can success of knowledge elicitation and transfer processes be assessed?

In addition to the theoretical construct there were two other sources of input to the answer of the additional research questions. These were:

- The findings of the literature review, reported in chapter III of this dissertation.
- The development and refinement of CoMEx during the field work, reported in chapter V of this dissertation.

Table 6.6 shows how the secondary research questions were addressed, at least partially, using these three main sources of input.

Table 6.6. How the secondary research questions were addressed

Secondary research question	Sources that contribute to the answer
RQ-1	Literature review, field work, TC-1, TC-2, TC-6, TC-9
RQ-2	Literature review, field work, TC-8, TC-9, TC-10
RQ-3	Literature review, field work, TC-1, TC-2, TC-8, TC-9
RQ-4	Field work, TC-4
RQ-5	Field work, TC-5
RQ-6	Literature review, field work, TC-6
RQ-7	Literature review, field work, TC-10

Dealing with the main research question

The main research question had been defined in chapter I as:

“How can the limitations of existing approaches to knowledge elicitation and transfer in organisations be overcome?”

It had also been analysed in chapter I how the secondary research questions derived from the main research question. As a result, it was found during the data analysis that answers to each of the secondary research questions contributed to the answer of the primary research question.

In order to address the primary research question the following conclusions were drawn based on the assessments from participants in the multiple case study as it has been described in this chapter:

1. Face-to-face, facilitated and collaborative modelling of domain knowledge is a valid approach for the elicitation of different types of knowledge from experts and the transfer of such knowledge to some of its stakeholders.

2. CoMEx is a successful method for the implementation of face-to-face, facilitated KET through collaborative modelling of domain knowledge.
3. CoMEx overcomes some of the main limitations of existing approaches to knowledge elicitation and transfer.

Table 6.7 is intended to help the reader understand the extent to which the data collected shows that CoMEx overcomes the limitations of existing approaches to KET. The analysis is based on the comparison of observed outputs of CoMEx during the field work and known deficiencies of other approaches as identified in the review of the literature. For additional information on the latter please refer to the contents of chapter II of this dissertation.

Table 6.7. How CoMEx overcomes the known limitations of knowledge elicitation and transfer techniques

Limitations of existing KET techniques	Knowledge elicitation and transfer approaches that face these limitations	Evidence that suggests that CoMEx overcomes these limitations
<p>The characteristics of the knowledge sought to be elicited and transferred limit the success of KET techniques</p>	<p>The applicability of knowledge and its learnability limits the outputs of methods that were used within the field of Expert Systems to elicit knowledge from experts.</p> <p>The variety and complexity of the knowledge to be elicited limits success of the methods applied to elicit knowledge from individuals within the Information Systems requirements engineering.</p> <p>The perceived validity, quality, learnability and retrievability of knowledge limits success of methods applied to elicit and transfer knowledge within the Knowledge Management field.</p> <p>The rational, emotional and political issues that characterise the knowledge being transferred affects the success of Action Learning as a knowledge elicitation method.</p> <p>The psychological validity of the knowledge may impact success of the methods applied in the field of training and development, as the newly acquired knowledge is not always likely to be applied.</p> <p>The volume and issues related to the maintenance of knowledge stored in social software affect the value of these as knowledge elicitation and transfer tools.</p>	<ul style="list-style-type: none"> • CoMEx has been successful in the elicitation and transfer of knowledge relating to different aspects of the organisation's activities and in different contexts. These included knowledge relating to: • The process of diagnosing faults in gas turbines or dealing with a customer query in engineering organisations. • The operation of products such as gas turbines at GTM. • The process of delivering infrastructure to soldiers in the field in a project-based organisation. • The skills and abilities of individuals and their potential contributions to a project in a project-based organisation. • The data collected highlights that individuals and organisations involved were ready to apply the newly acquired knowledge immediately after the KET exercises, and continued to do so at least until the writing of this dissertation was completed.

Table 6.7. How CoMEx overcomes the known limitations of knowledge elicitation and transfer techniques

Limitations of existing KET techniques	Knowledge elicitation and transfer approaches that face these limitations	Evidence that suggests that CoMEx overcomes these limitations
<p>The high demands that the knowledge elicitation and transfer processes impose on participants.</p>	<p>The time and skills required to describe knowledge in a structured way and add information on the context of the specific experience limited success of the methods used within the field of Expert Systems to elicit knowledge from experts.</p> <p>The complex patterns of interaction among analysts and individuals who have the knowledge during the knowledge elicitation process affects success of the methods applied within the Information Systems requirements engineering field.</p> <p>Time, skills and resources required by experts to contribute knowledge, and time and effort required by stakeholders affect the success of methods applied within the Knowledge Management field.</p> <p>The stresses and demands that an action learning project can impose on participants limit success of the Action Learning method to elicit knowledge.</p> <p>As within the KM field, the use of social software for knowledge elicitation and transfer is affected by the time, skills and effort required from the individuals involved.</p>	<p>Based on the experience of the organisations involved in the multiple case study, implementing a CoMEx exercise involved a number of staff for relatively short periods of time.</p> <p>The analysis of discussions held during the KET sessions would potentially yield additional results. It is acknowledged that such an analysis would require a significant amount of additional time. However, data collected suggests that organisations were satisfied with the direct outcomes of the KET sessions, and that perceived value of such outcomes is higher than the cost of the exercises.</p>

Table 6.7. How CoMEx overcomes the known limitations of knowledge elicitation and transfer techniques

Limitations of existing KET techniques	Knowledge elicitation and transfer approaches that face these limitations	Evidence that suggests that CoMEx overcomes these limitations
<p>Problems related to the selection of experts and to their ability to contribute their knowledge.</p>	<p>Knowledge elicitation methods used in the field of Expert Systems were affected by relying in the views of a single expert as they were unable to reconcile different and sometimes conflicting views.</p> <p>Conflicting views of different users were also a limiting factor in the elicitation of knowledge in the field of Information Systems requirements engineering.</p> <p>The potential difficulties in identifying experts in the workplace affects the methods applied to elicit and transfer knowledge within the Knowledge Management field.</p> <p>Action Learning projects are affected by what has been termed 'the expert solution': when experts are part of the problem-solving groups, members look to them for solutions rather than learning and discovering fresh solutions on their own.</p> <p>Success of social software as knowledge elicitation and transfer tools is affected by the ability of individuals with expertise in a specific area to communicate their knowledge.</p>	<p>CoMEx is a structured process that relies on the organisation's awareness of its needs to share specific knowledge between specific individuals. It does not include a stage or guidelines concerned with the selection of participants. Instead, it understands that the organisation itself has the best possible view of the expertise of its employees and is therefore in the best position to appoint those that will participate as experts. Although this may still be considered as a limitation, CoMEx offers an alternative view to some of the existing techniques that rely on expertise spontaneously emerging from unknown organisational sources.</p> <p>Once the KET team has been formed, the structure of the method, the nature of the collaborative modelling exercises and the facilitation techniques applied seek to maximise the experts' contributions.</p> <p>Evidence collected during the field work shows that most experts have been able to contribute their knowledge throughout the different stages of each of the KET exercises.</p> <p>The method helps to create a consensus of views, thus reducing the problem of conflict between experts.</p>

Table 6.7. How CoMEx overcomes the known limitations of knowledge elicitation and transfer techniques

Limitations of existing KET techniques	Knowledge elicitation and transfer approaches that face these limitations	Evidence that suggests that CoMEx overcomes these limitations
<p>Motivational issues related to the elicitation of the knowledge from experts and its acquisition and application by individuals and workgroups.</p>	<p>How to motivate individuals to contribute their knowledge has been one of the most important issues to resolve in most fields that have relied on the elicitation of knowledge, such as KM or the use of social software. Similarly, users of the knowledge newly elicited from experts often refuse to apply it due to a number of reasons.</p> <p>In particular within fields such as Expert Systems failure has been related to the fact that individuals are often restrained by their motivation when striving to express, apply, and explain their knowledge.</p>	<p>Based on the evidence collected throughout the field work, all participants in each of the applications of CoMEx were significantly motivated to share their experience and learn from others, and all of them would recommend others to participate in similar exercises.</p> <p>The data collected shows that during each KET session experts contributed to the debate for more than 50% of the time as an average. Experts also asked and were willing to learn from others doing, for example, different types of research.</p> <p>As for stakeholders, data collected shows that in most cases they found it useful to have the opportunity to discuss issues directly with the experts (which also contributes to the assessment of the approach to selecting the experts). Furthermore, in those organisations where evaluation was conducted after a significant period of time, it was found that stakeholders had continued to contact experts when their knowledge was required, and they found it easier to do so than it was in the past.</p>

The conclusions of this research, which address the primary research question, have been derived from the clustering of the theoretical constructs as shown in table 6.8. While doing this, the researcher sought to ensure that there was enough evidence in the data collected to support each conclusion. Thus the conclusions drawn would not only be conceptually coherent but also supported by the perception of participants in the multiple case study.

Table 6.8. How conclusions have been derived: the clustering of theoretical constructs

Theoretical constructs	Resulting conclusions
<p>TC-1. In the conditions of the organisations involved in the multiple case study face-to-face, facilitated and collaborative modelling domain knowledge is a potentially valid approach to the elicitation of knowledge from experts and its transfer to other individuals and workgroups.</p> <p>TC-2. CoMEx is a valid implementation of a knowledge elicitation and transfer approach which is based on face-to-face, facilitated and collaborative modelling the knowledge domain.</p> <p>TC-3. In addition to the elicitation and transfer of knowledge, running a CoMEx exercise has the potential to bring other benefits to an organisation, including the following:</p> <ol style="list-style-type: none"> 1. Outcomes which may become an explicit source of knowledge for reference by members of the organisation. The following were identified during the field work: <ol style="list-style-type: none"> a. Models of different aspects of the knowledge domain. b. Recordings of discussions held during the KET sessions. 2. The development of new and existing communities driven by the interests of some of the project participants in giving continuity to the knowledge exchange in an informal basis. 3. A particular outcome in the KET exercise at MoDInfra was the formation of a team of individuals committed to achieve a common, institutional purpose. <p>TC-4. KET projects are more likely to be successful if they target specific individuals/workgroups and have a clearly defined focus. The organisation has an important role to play in the selection of participants and the knowledge domain on the basis of its own knowledge needs.</p> <p>TC-5. CoMEx has been perceived as a successful method to be used for the elicitation and transfer of knowledge relating to different aspects of the organisation's activities. In the particular case of the organisations involved in the field work, four different areas were addressed. These included: Process-related knowledge, Product-related knowledge, Project- and programme-related knowledge and Knowledge about individuals' skills and abilities.</p> <p>TC-6. Knowledge elicitation and transfer can be successfully implemented without relying on the use of information and communication technologies.</p> <p>TC-9. A KET facilitator or moderator plays a major role in the success of a KET exercise based on the</p>	<p><i>Conclusion 1:</i></p> <p>Face-to-face, facilitated and collaborative modelling of domain knowledge is a valid approach for the elicitation of different types of knowledge from experts and the transfer of such knowledge to some of its stakeholders.</p> <p><i>Conclusion 2:</i></p> <p>CoMEx is a successful method for the implementation of face-to-face, facilitated KET through collaborative modelling of domain knowledge.</p>

Table 6.8. How conclusions have been derived: the clustering of theoretical constructs

Theoretical constructs	Resulting conclusions
<p>implementation of CoMEx. The role of a KET facilitator is one of co-ordinating and supporting the process by which experts and stakeholders share knowledge on a face-to-face basis.</p>	
<p>TC-4 KET projects are more likely to be successful if they target specific individuals/workgroups and have a clearly defined focus. The organisation has an important role to play in the selection of participants and the knowledge domain on the basis of its own knowledge needs.</p> <p>TC-5. CoMEx has been perceived as a successful method to be used for the elicitation and transfer of knowledge relating to different aspects of the organisation's activities. In the particular case of the organisations involved in the field work, four different areas were addressed. These included:</p> <ol style="list-style-type: none"> 1. Process-related knowledge. 2. Product-related knowledge. 3. Project- and programme-related knowledge. 4. Knowledge about individuals' skills and abilities. <p>TC-7. Based on the experience of the organisations involved in the multiple case study there is no evidence that suggests that the demands of implementing a CoMEx exercise have a negative effect in the achievement of its aims. Furthermore, the field work suggests that such demands are not significant when compared to its potential benefits.</p> <p>TC-8. On the basis of the data collected, individuals involved in knowledge elicitation and transfer using CoMEx feel motivated to contribute their knowledge and learn from other participants. CoMEx allows for a communication and adoption of ideas to take place.</p>	<p><i>Conclusion 3:</i></p> <p>CoMEx overcomes some of the main limitations of existing approaches to knowledge elicitation and transfer.</p>

6.3.2. Verification of the conclusions

Meaning has been generated from a large set of data. The findings of the research have been interpreted. A large section of this chapter has focused on describing *how* the researcher arrived at such findings. However, actions were taken during the final stage of the data analysis to confirm the findings, thus addressing an issue that affects qualitative research: the validity of conclusions.

There are many different tactics for testing or confirming the findings of qualitative research. These include triangulation, weighting the evidence, using extreme cases, looking for negative evidence and many others. Most of these have as their ultimate aim addressing concepts such as the representativeness, reliability and replicability of the findings. A review of the different approaches that exist is beyond the scope of this section.

There are no agreed-upon mechanisms to indicate whether findings of qualitative research are valid and procedures robust (Huberman and Miles, 1983; Miles and Huberman, 1994; Yin, 2009). Therefore, the researcher followed a process that has been classified by Miles and Huberman (1994, p.275) as “*one of the most logical*” and “*venerated, but not always executed*” in qualitative research: feeding the major findings of the research back to key participants in the multiple case study, looking for their evaluation. Ultimately, this process also adds an ethical dimension to the research: organisations that sponsored a collaboration with the researcher in a KET exercise have the right to know what the researcher has found. This principle applies to all organisations that participated in the multiple case study, no matter how long ago, from GTM Ltd in early 2007 to MoDInfra in late 2009.

The researcher then prepared, after concluding the data analysis, a document that lays out the findings clearly and presented them to three individuals with significant involvement in the research for their careful scrutiny and comment. These individuals were:

- The manager of the remote monitoring department at GTM Ltd, who sponsored and participated in the KET exercise.

- A member of the KM team at PowerTech UK Ltd, who was involved in the implementations of CoMEx as a stakeholder and as a facilitator.
- The Programme leader at MoDInfra, who sponsored and participated in the implementation of CoMEx.

These individuals responded using e-mail. Their responses are available in appendix A, within the folder

Verification of conclusions /

Some of the key issues highlighted by those individuals in relation to the conclusions of this research include:

- I agree with your summary of conclusions of the research. *GTM Ltd.*
- I have read your conclusions carefully and very much agree with them. *MoDInfra.*
- The discipline of the CoMEx approach has better enabled us to embrace and address the necessary changes. *MoDInfra.*
- Through the use of CoMEx the team was able to quickly understand what the challenges facing the engineers were. It included issues ranging from motivation, trust, politics, to knowledge sharing. *PowerTech UK Ltd.*
- I think CoMEx provides a genuine and sustainable tool for knowledge capture and knowledge retention. It is cheap to implement as it has very low variable costs. *PowerTech UK Ltd*
- We are still interested in replicating that [knowledge elicitation and transfer] exercise. It was very useful and I hope senior management will one day invest in this or a very similar approach. *GTM Ltd.*

The researcher considered that these views were representative of the perception of the organisations involved in the research, and therefore the conclusions presented in this chapter are considered valid. With this step, the data analysis was concluded.

6.4. Summary of key issues reported in this chapter

This chapter has described in detail how the data collected during the field work was analysed. The body of data collected as a result of the implementation of a multiple case study was reduced to manageable contents that were then displayed using tables. Data were analysed for every individual application of CoMEx. This was then followed by a cross-case analysis. Theoretical constructs were derived from the analysis. Some of these, in conjunction with the findings of the literature review and the field work, provided answers to one or more of the additional research questions that drove the research. The conclusions of the field work, which address the main research question, were finally drawn from those theoretical constructs. The chapter finally described how the validity of the conclusions drawn from the data collected was assessed.

Chapter VII will then discuss the main issues that emerged from this research and also analyse the areas that will benefit from further study.

Chapter VII

DISCUSSION AND FURTHER WORK

This chapter summarises the results of the research conducted in this project. Such a summary is based on the overview of the path taken in the research, leading to a discussion of its primary contributions. The chapter also discusses the limitations of the research conducted, and provides areas for further research.

7.1. Overview of the path followed in the conduct of the research

The starting point of this research was the implementation of a knowledge elicitation and transfer strategy based on the use of social software. At the time of the collaboration between the researcher and Cranfield Academic Information Systems the deployment of a Wiki seemed the most appropriate manner to address the issue of knowledge sharing between students from different departments. However, as the excitement associated with the launch of the new tool faded away the limitations of purely technology-based approaches to KET became evident. Within a matter of months the PhD students' Wiki lost its attraction for the potential stakeholders whose knowledge it sought to contain.

A collaboration with GTM Ltd then provided the impetus for the formulation of a new, more generic research problem: How can knowledge be successfully elicited from those considered as experts and transferred to other organisational participants? The lessons learned from that project suggested that models of the knowledge domain could play a key role in the KET processes. The review of the literature on these topics raised awareness of the issues that limit success of existing approaches to KET. This led to the formulation of a more precise research question as follows: How can the limitations of existing approaches to KET in organisations be overcome? A number of additional research questions and a conceptual framework were derived from the analysis of the

main research problem. These defined the boundaries within which the KET problem was to be studied by this research.

Subsequent stages of the research project were concerned with the development of a new approach based on implementation of KET projects with different organisations. The new approach was built upon the lessons learned from the GTM Ltd project, which meant that it was based on facilitated, face-to-face, collaborative modelling of domain specific knowledge involving experts and potential stakeholders of their knowledge.

A new method called Concepts-Modelling-Experience (CoMEx) was developed as a practical mechanism for implementing the new approach to KET. In later stages of the research the analysis was based on comparing the deficiencies of well known approaches to knowledge elicitation and knowledge transfer as reported in the relevant literature with the observed outputs of the implementation of CoMEx in different types of organisations.

In general terms, it can be concluded that the path taken in this research has been driven by three key factors. These are:

- The importance of the processes for eliciting knowledge from experts and transferring it to other individuals and workgroups for its reuse in organisations.
- The lack of a well-established mechanism for KET and the limitations of existing approaches.
- The observed success of a people-based approach to KET based on facilitated, collaborative modelling of the knowledge domain.

7.2. Summary of key contributions of the research

The primary contribution resulting from this research was related to its dealing with the main research question: A new approach to KET was defined. Field trials of the new approach carried out so far suggest that it has certain advantages over the techniques applied in other areas.

However, additional contributions have resulted from the collaboration of the researcher with the four organisations involved in this research. This section will review these in some detail.

7.2.1. Contributions to the body of knowledge in the field of KET

A successful mechanism for the elicitation and transfer of knowledge across individuals and workgroups has been developed, refined and validated in the field. This approach is based on the collaborative development of models of the knowledge domain, which constitutes the key to overcoming some of the known limitations of other approaches. Also, the approach has a people-based perspective with no dependence on the use of information and communication technologies, but does require a KET facilitator or moderator.

In order to help organisations understand how this new approach to KET can be applied in practice, this research designed a method that defines a set of steps that organisations can run. These are:

1. Identifying key **concepts** within the knowledge domain.
2. Using those concepts as a starting point for the collaborative development of one or more **models** of domain knowledge.
3. Analysing the connections between these models and the **experience** of individuals involved in the KET exercise.

The KET method developed has been called CoMEx, which stands for Concepts-Modelling-Experience.

A review of the main areas in which the KET problems have arisen became a necessary step in the development of CoMEx. This resulted in a summary of the advantages and limitations of KET techniques that have been used in different fields, including Knowledge Management, Expert Systems development, Information Systems requirements engineering, and Training and Development. The outcomes of such a review become, in themselves, an additional contribution to the body of knowledge in the field of KET.

A comparison of the observed outputs of the implementation of CoMEx in the field and the known deficiencies of other approaches as described in the literature was conducted. Its results suggest that CoMEx overcomes some of the main limitations of existing techniques for KET. In particular, that CoMEx has been, so far, successful in:

1. Eliciting and transferring knowledge relating to different aspects of an organisation's activities, including knowledge about processes, products, projects and programmes, and also knowledge about skills of particular individuals.
2. Running with a reasonably modest number of requirements in terms of time, effort and other resources from the organisation and the individuals involved in the KET process.
3. Motivating experts to contribute their knowledge and also stakeholders to acquire and reuse the knowledge of experts.
4. Increasing the ability of experts to contribute their knowledge.

7.2.2. Contributions to the success of the organisations involved in the research

Throughout the research reported in this dissertation collaborations with four different organisations were established and successfully completed. The multiple case study involved, chronologically, the following knowledge-intensive organisations:

1. GTM Ltd. A major gas turbine manufacturer based in the UK, part of a global organisation.
2. Cranfield University. An academic institution where the researcher was based.
3. PowerTech UK Ltd. A power conversion systems manufacturer based in the UK, part of a global organisation.
4. MoDInfra. A section within a project management organisation in the defence industry.

Based on the assessments of individuals from those organisations, in addition to the elicitation and transfer of knowledge, the application of CoMEx had secondary, positive effects that included the following:

1. Some outcomes of the process of applying CoMEx became an explicit source of knowledge for reference by members of the organisation. The following were identified during the field work:
 - a. Models of different aspects of the knowledge domain relevant to each organisation.

- b. Recordings of discussions of relevant topics that were held involving key organisational participants.
 - c. The formation of a team of individuals at MoDInfra, committed to achieve a common, institutional purpose.
2. The development of new and existing communities driven by the interests of some of the project participants, which in some cases gave continuity to the knowledge exchange initiated by the application of CoMEx.

All the organisations involved in the multiple case study argued that they benefitted from the project to such an extent that they were now aware of the need to institutionalise, as part of their daily work, the KET activities facilitated by the application of CoMEx.

Their involvement in this research became, for some of those organisations, a pilot study that raised awareness of the importance of eliciting, sharing, reusing and managing knowledge for their success.

7.3. Limitations of the research

The limitations of this research are determined by the following two broad issues:

- The nature of the domain of KET in organisations.
- The practicalities of the implementation of KET projects in organisations.

7.3.1. The nature of the domain of KET in organisations

Knowledge elicitation and knowledge transfer have been addressed by this research as two interconnected processes related to the creation, sharing, evaluation, dissemination and adoption of knowledge.

There are in the literature many definitions of knowledge and these vary widely from one author to another. Thus, understanding what each of those concepts (i.e. knowledge creation, sharing, evaluation, dissemination and adoption) means and how they could be

studied proved challenging. The same principle applies to the analysis of what expertise means and what defines an expert.

The human nature of knowledge and the difficulties associated to the measurement of success of its elicitation and sharing also became evident during the implementation of the research. While organisations such as GTM Ltd gave high priority to their KET project, for PowerTech UK Ltd CoMEx became yet another tool, with relatively little attention by management during its implementation stages.

Additionally, the researcher found that factors such as organisational structures and practices had a major effect in the way KET projects were conducted and their outputs. For example, the Customer Service departments of two manufacturing organisations were involved in the research at different stages of the multiple case study. Customer Service had a different place within each of these two organisations' structure: it was an autonomous department in one of them, whilst in the second manufacturing organisation, Service was partitioned in small teams that responded to different sections. That difference meant that, although both Service departments dealt with customer queries, their working practices had significant differences. Those differences were reflected in the behaviour of participants in the two KET projects and therefore in their results in aspects such as the volume of data collected.

Consequently KET is a research area that shares a significant number of features with other domains such as psychology or organisational studies. Some of these features could only be studied to a limited extent as part of the conduct of this research. These include:

- The personal characteristics of individuals, such as their physical, personality and demographic (e.g. age, sex, socio-economic status).

Issues such as individuals' cognitive and communication styles, and motivational issues determine their behaviour during KET processes and their outcomes. This research has studied the issues related to personal characteristics of individuals to a limited extent.

- Group dynamics.

How individuals act or behave has a major effect on the elicitation and transfer of knowledge and, as a consequence, in the results of these processes. The researcher was aware of the importance of group-related issues such as cohesiveness, compatibility, homogeneity/heterogeneity, and environmental influences for the success of KET. However, this research could only deal with these to a limited extent.

Issues related to facilitation of group dynamics during KET exercises could also be studied only to a limited extent. These include what the right number of facilitators is, how they are best selected, what their role within the KET project is, and what training and preparation are required.

- How individuals and groups act within organisations.

The study of how individuals and groups act in the context of an organisation is related to issues such as cooperation/competition between individuals and groups, organisational structures and organisational politics. The researcher was aware that these features can determine the success of implementation of a KET project in an organisation. However, these issues were covered only to a certain extent in this research.

7.3.2. The practicalities of the implementation of KET projects in organisations

Knowledge elicitation from experts and its transfer to individuals and workgroups can only be studied as these processes take place within a real-life context. In order to achieve this, the author needed to gain access to a wide range of sources of evidence that included documents and artefacts, but also interviewing participants and observing the development of the KET process. These sources of evidence could only be found in organisations. However, the difficulties in measuring the success of a KET project made it sometimes difficult for organisations to commit to a collaboration with a researcher, particularly during early stages of the research. This, together with the time and resources required from the researcher to conduct additional KET projects as part of the multiple case study, made it necessary to report the research after the collaboration with MoDInfra was concluded, even when other field work opportunities were in sight.

As a result, the following issues related to the practicalities of the implementation of CoMEx in organisations could only be studied to a limited extent:

- Knowledge domains which can benefit the most from the implementation of CoMEx.
- Knowledge representation schemes and choices of models that could enhance or hinder the success of KET meetings.
- The criteria to define when the knowledge has been elicited from experts and transferred to other individuals, which determines the number and length of the meetings required for this to be achieved.
- The differences in the outcomes of combining modelling and analysis of individuals' experience in the same session as opposed to carrying out each of these activities in separate meetings.

The researcher therefore acknowledges that more applications of CoMEx in the field, particularly within organisations from a broader range of contexts, would have been beneficial for its further development and assessment. Although the development of CoMEx had stabilised at the time of the collaboration with MoDInfra, a more diverse context could uncover new dimensions for further development.

7.4. Areas of future work

The researcher has identified two areas that are worthy of further research. These are:

- The study of the factors which are likely to influence the effectiveness and efficiency of the new approach to KET.
- The study of the factors which are likely to influence the applicability of the new approach in other contexts.

7.4.1. Effectiveness and efficiency of the new approach to KET

Following on from the analysis of the limitations of the research described in the previous section, success of the new approach to KET would benefit from the further study of three groups of features. These are:

- How the personal characteristics of individuals affect the success of the KET project, and how can the new approach be modified to consider this.

Running a KET exercise using CoMEx within organisations with a more diverse workforce, e.g. including people from different ages and backgrounds, could provide the setting to study the effects of personal characteristics in the KET process.

Also, providing guidelines for the selection of CoMEx participants, and in particular the experts, could help making the method more efficient.

- How the dynamics of a KET team as a group affect the success of the KET project, and how the new approach can be modified to consider this.

So far all applications of CoMEx involved people who had been in contact with each other, at least informally, in the past. Exercises where the KET teams are composed of people who do not necessarily know each other would add new variables to the analysis of CoMEx.

- How the issues related to how people act within the context of an organisation affect the success of the KET project, and how the new approach can be modified to consider this.

Organisations where cooperation is required but there is a known competition between different teams and units could provide an ideal setting for the study of the success of CoMEx in motivating people to share their expertise.

It is also important that issues related to the organisation and implementation of a KET exercise following the new approach are also studied further. This includes, among many others, the level of support that is required from management for a KET project to be perceived as successful, the number and duration of the KET sessions, and the feasibility of implementing the approach using mechanisms available to hold virtual meetings for teams whose participants are geographically distributed. Any lessons learned in this area would also need to be embedded in the definition of the proposed approach to KET as they emerge.

Other issues that will also benefit from further study include:

- How the success of CoMEx as a KET method can be best evaluated.

If costs and benefits derived from the implementation of CoMEx in a particular context could be quantified, what would be the results of a cost-benefit analysis and how could these results be transferred to other contexts?
- How the scope of the new approach to KET can be expanded to also help the organisation to transfer the knowledge newly acquired by CoMEx participants to other individuals and work groups.
- The types of models and knowledge representation schemes that can work better in:
 - Facilitating KET within the teams participating in KET sessions.
 - Helping the organisation to transfer knowledge from participating groups to other individuals and work groups.
- Providing guidance on the best way to choose the knowledge representation scheme in each domain.

Given the success of CoMEx as a team building exercise within MoDInfra, the trial and evaluation of the method as a team building tool is also recommended as an area of further research.

7.4.2. Applicability of the new approach to KET in other contexts

During the conduct of this research it was possible to apply the proposed approach to KET successfully in four organisations, according to the following distribution:

- A manufacturing organisation, addressing the elicitation and sharing of product-related knowledge.
- A research organisation, addressing the elicitation and sharing of process-related knowledge.
- A manufacturing organisation, addressing the elicitation and sharing of process-related knowledge and knowledge about information needs of individuals.

- A project-based organisation, addressing the elicitation and sharing of project-related knowledge and knowledge about individuals.

Thus, the KET exercises reported in this dissertation have largely fallen within engineering or related areas. At this stage the proposed approach to KET would benefit from a study of its applicability in other organisational contexts and addressing knowledge related to other aspects of the organisation's activities.

7.5. Concluding remarks

This thesis has reported a successful research project that spanned over four years, involving knowledge workers from four major organisations. This project has made a significant contribution to the body of knowledge available in the knowledge management domain. Furthermore, there have been specific benefits for all stakeholders, derived from their relationship with the PhD research reported.

For the researcher, this project has meant an opportunity to consolidate his academic background with invaluable industrial experience, enabling him to conduct rigorous and relevant research in the future.

For the Department of Informatics and Systems Engineering at Cranfield University this has been an innovative project which has successfully uncovered an area that is likely to bring new opportunities for teaching and research, as well as further collaboration with industry.

Individual researchers at Cranfield University also benefitted from their participation in the project. By the time this project was completed, all but four of the PhD research students who participated in the KET exercises had already completed their PhD research successfully. Although it is difficult to relate such a success directly to their participation in a CoMEx exercise, it may well have been one of the contributing factors.

Middle and senior management at GTM Ltd realised, by participating in this project, the potentials of its tacit knowledge base. The company also understood the importance of the lessons learned by its Service engineers on a daily basis for all its engineering

activities. The company is currently exploring the feasibility of running new projects under the banner of 'learning from use of GTM products'.

PowerTech UK Ltd found in the KET exercises a successful experience that has been replicated in other occasions including international PowerTech engineers. Additionally, the models produced during the exercises have been used with the dual purpose of understanding best practices across the company and evaluating the results of the PowerTech KM project.

With the implementation of the KET exercises, MoDInfra had a successful start of their programme. This helped them complete their commitments during the first year of the programme successfully. They have recently acknowledged that the models produced during the exercise helped them implement, during the initial stage, not only the expected tasks but also the necessary changes to the plan.

This research started by focussing on the way in which computer-based technology could be used to improve knowledge capture and transfer. Its emphasis changed from looking at technological aids to looking at the people and processes involved in capturing or transferring knowledge. In that respect it followed the same path that many other researchers in the field have travelled. The particular contribution of this research has been to design and test out a process to aid people in the transfer of knowledge. Initial trials have yielded good results and suggest that the approach has real value. In particular it allows knowledge transfer initiatives to be targeted in a way which was not possible with standard approaches. The full potential and implications of the approach have still to be explored.

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Appendix A

DATA COLLECTED AS A RESULT OF THE FIELD WORK

Introduction

A DVD is enclosed with the aims of supporting and complementing the information contained in the body of the PhD thesis.

The DVD contains a description of all the data collected and analysed during the field work and a sample of these data for the purposes of illustrating the data collection and analysis processes.

Organisations where the data originated

- GTM Ltd
- Cranfield University
- PowerTech UK Ltd
- MoDInfra

Relevant dates

Organisation	Dates
GTM Ltd	February 2007 to March 2008
Cranfield University	February 2008 to November 2008
PowerTech UK Ltd	August 2008 to February 2009
MoDInfra	December 2008 to November 2009

Contents of the DVD

For every organisation involved in the research the following information is included, at least partially, in the DVD:

- **Original data collected.** Includes, for every implementation of CoMEx, the e-mail communication held, reports written after meetings, researcher's notes, voice recordings, photographs taken and documents/records reviewed by the researcher with the aim of supporting the implementation and evaluation of CoMEx.

- **Results of the data reduction and transcriptions.** This is a subset of the data collected. It includes all the data (or transcriptions where appropriate) that were:
 - Collected during the implementations of CoMEx, and
 - Considered as relevant for at least one of the following purposes:
 - a. Addressing the research questions
 - b. Refining CoMEx
- Results of the coding of the relevant data (**first-level coding**). This data set is quantitatively similar to the one that was already presented as ‘data reduction and transcriptions’. However, the documents included in this data set have been coded following the process described in chapter VI of the thesis. For the coding of this data set, these documents were printed, coded in paper, and scanned to include in this appendix a copy in electronic format.
- **Results of the data analysis.** This is a single file containing a table that summarises the patterns identified from the data collected in each particular organisation.

Additionally, the following information is included in the DVD:

- **Cross-case analysis.** A table that includes the summary of patterns that were common in the data collected in all the individual case studies and contributed to addressing the research questions.
- Confirmation of **permission** granted by the organisations involved in the research **to publish** the sections of the thesis that are concerned with their participation in the study. The information included covers GTM Ltd, PowerTech UK Ltd and MoDInfra. In the case of Cranfield University, approval granted by the PhD supervisor to submit this work was considered sufficient for this purpose.
- Information useful for the **verification of conclusions**.

On completion of the PhD thesis the researcher contacted one individual from each of the three organisations involved in the research. A summary of the

conclusions of the research was provided, with a request for feedback. The positive feedback received from three organisations is included. As with the permission to publish (see above), the information included covers GTM Ltd, PowerTech UK Ltd and MoDInfra.

In the case of Cranfield University, the extensive feedback received during the interviews conducted six months after the KET exercises was considered enough for this purpose.

Finally, each folder contains a folder summary form describing its contents, based on the following information:

Folder information:

Folder name:	
Folder location:	

Folder contents information:

Organisation where the data originated:	
Contents are valid for the following purposes:	
Relevant dates:	
Original contents:	
Format(s):	
Brief description:	

Elements included in this folder for the purpose of PhD assessment:	
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Format of the information included in the DVD

The DVD contains information in the following formats:

- Microsoft Word (2003 version): Documents such as reports, interview transcripts etc produced by or provided to the researcher during the field work.
- WAV: Voice recording of interviews and discussions held during KET sessions.
- PDF: Documents saved after being coded and scanned. Also e-mails were saved in this format.
- Microsoft PowerPoint: Presentations delivered in different contexts.
- JPG: Photographs taken during the implementations of CoMEx in the field.

Appendix B

KEY IDEAS AND THEMES FROM THE IMPLEMENTATIONS OF COMEX IN THE FIELD

B.1. Key ideas and themes from the knowledge elicitation and transfer project at GTM Ltd

I. CoMEx approach: The implementation of knowledge elicitation and transfer based on collaborative modelling the operation of gas turbines	
A. Outcomes of the application of CoMEx	<p>The outcomes identified by individuals can be grouped into four main categories:</p> <ol style="list-style-type: none">1. Learning by experts: Experts involved were aware of their role within the project as sources of relevant knowledge to be elicited. However, two main reasons made them feel motivated to participate and contribute:<ul style="list-style-type: none">- The project aimed to produce a fault diagnosis system based on their knowledge, which could reduce their workload. This emerged from comments such as the following: <i>“It will definitely help them [customers] to stop ringing me at 3am and pulling me out of bed when I am on call”</i> <i>“It will help the Help Desk in terms of time saving in getting to the root cause of failures”</i> <i>“This will reduce the out-of-hours workload. Or just reduce the workload”</i>- They had rarely discussed the topic of gas turbine operation from a perspective other than related to specific problems. Comments such as the following were made by experts: <i>“Very rarely you get to dig into everything surrounding what you do”</i> <i>“It is good to take a step back and look at the whole system [gas turbine]”</i>2. Learning by stakeholders: Stakeholders claimed that their participation in the exercise increased their knowledge base. Also, they mentioned

B.1. Key ideas and themes from the knowledge elicitation and transfer project at GTM Ltd

	<p>that it changed or added to their views on the way the system operates and how it can fail. The following comments were extracted from the data collected:</p> <p><i>“The information was useful for the things that some of us are doing”</i></p> <p><i>“It changes your views on the way the system operates and how it can fail”</i></p> <p><i>“It just helps to build an extra piece of the jigsaw”</i></p> <p>3. New explicit resources became available:</p> <p>A Bayesian network that captures the symptoms and root causes of specific faults in gas turbines was developed. Many uses were identified for such a model, including the one described by the following comment from a GTM manager:</p> <p><i>“We can put this Bayesian network in a kind of commercial form and start to invest in putting its information somewhere into our system”</i></p> <p>Over 10 hours of recordings of Help Desk expertise are available to GTM engineers and managers for future reference.</p> <p>4. New communities of interest:</p> <p>This was the first attempt to bring together Help Desk experts and engineers from other GTM departments in order to discuss issues of common interest. After the exercise, all engineers felt that it had become easier to talk to the Help Desk when needed.</p> <p><i>“We need to get the experts together: design, service, software people to come up with what is that we have to do and how”</i></p> <p><i>“It now seems easier to know who knows about what when we have a core engine problem”</i></p>
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B.1. Key ideas and themes from the knowledge elicitation and transfer project at GTM Ltd

B. Modelling	<p>The process of developing a model of fault diagnosis in the form of a Bayesian network led to</p> <ul style="list-style-type: none"> - More than 10 hours of discussion of failure modes and their root causes between individuals from different departments. - Expertise of Help Desk engineers challenged the perception of engineers from other departments about key areas of the domain that were represented by either nodes or quantitative values in the Bayesian network. Understanding of established knowledge in Design and Manufacture was modified as a result of agreeing in graphically representation of specific causes of failure modes. <p>Participants highlighted this through comments such as the following:</p> <p><i>“It changes your views on the way the system operates and how it can fail”</i></p> <p><i>“This has been a good way of extracting their knowledge”</i></p>
C. Participants	<p>Participants were selected by the managers of at least two of the departments involved: The help desk and the controls department.</p> <ul style="list-style-type: none"> - In terms of the selection of experts, management was aware of the value of the expertise of Help Desk engineers and therefore selected some of the most experienced in the department to participate in the project. - With regard to stakeholders, design, development and manufacture engineers were selected by managers on the basis that they are some of the key stakeholders of the knowledge about gas turbine operation.
D. Type of knowledge	<p>Knowledge about the operation of gas turbines, their failure modes, causes, symptoms and solutions was elicited from service experts and transferred to other departments.</p>
E. Technologies	<p>Information and communication technologies were only used to support the preparation and running of the exercise. Email in particular was heavily used to organise every meeting and knowledge elicitation and transfer session.</p> <p>The only technology used during the running of the exercise was a voice recorder to keep a record of the discussion and with data collection purposes. Occasionally a data projector was also used.</p>

B.1. Key ideas and themes from the knowledge elicitation and transfer project at GTM Ltd

II. **Other approaches:** The limitations of other approaches to KET versus the application of CoMEx

GTM Ltd had tried two different mechanisms for the purposes of eliciting knowledge from experts in the past. Both projects had failed to provide the expected outcomes in the views of managers.

1. One of these relied in one “*passionate man*” doing the work. It failed when that person was not able to carry on.
2. The second one sought to elicit the knowledge from experts and make it explicit. It sought to motivate them to contribute by providing free food and drinks during the sessions. There was no record in the company of the knowledge elicited during that project.

The following comments from managers suggest that GTM Ltd considered CoMEx a successful approach:

“This has been a good way of extracting their knowledge”

“Very interesting process from the experience sharing”

“More useful was to know the process than the information itself that came out of it”

“We have always thought: ‘there is an engineering problem; this is the solution’. You [the researcher] have taken one step forward. If it isn’t that, what else could be?”

The following comments from managers suggest that it would be beneficial for GTM Ltd to run a process like CoMEx on a regular basis:

“We need to have a function, a section in charge of this kind of activities”

“We have an interesting base for a project here”

“We need to get this process institutionalised and we lack the drivers to achieve that, and it worked with your exercise. Knowledge sharing is a big topic and this process has told us where we can start”

A. Demands from participants	The KET exercise at GTM Ltd only required participants’ attendance to the 3 sessions. Although experts’ time has a cost for the organisation, in the words of managers it is not like “ <i>the long time</i> ” that other projects had taken in the past.
B. Experts	There is no evidence in the data collected to suggest that the KET exercise was limited by the ability of experts to contribute their knowledge. One of the key points that an expert highlighted as an interesting experience was: <i>“being able to tell the design people that certain things didn’t work as they thought”</i>

B.1. Key ideas and themes from the knowledge elicitation and transfer project at GTM Ltd

C. Motivation	<p>1. At an organisational level:</p> <p>A presentation was given to management at the end of the project in an attempt to relate CoMEx outcomes to critical success factors. Management discussed the value of the exercise and was willing to take it further.</p> <p><i>“Certainly this is a good work [...]. It has not only made us think about how we work but most importantly it has made us think about how we want to work in the future. A lot of potential has been realised. We know we can develop it further”</i></p> <p>2. At an individual level:</p> <p>Interviews on an individual basis were held six months after the end of the exercise in order to explore potential impacts of the KET project in ways of working. Six stakeholders argued that they had benefitted from it. One stakeholder had changed his role since the exercise and was not clear about the benefit for its current role.</p>
III. Group dynamics: CoMEx and the facilitation of group dynamics	
A. Variables affecting individuals' comfort zones	<p>At the time the KET exercise at GTM was run the method was being shaped. As a result there was not enough awareness of the importance of considering variables affecting individual comfort zones.</p> <p>However, the sessions were run in a relaxed and informal environment where individuals felt motivated to participate. There is no evidence in the data collected that suggest that intrapersonal, interpersonal or environmental variables affected the contribution of any of the individuals involved or the success of the exercise.</p>
B. The role of the facilitator	<p>At this early stage of the development of CoMEx the role of the facilitator was focused on the elicitation of knowledge from experts in order to build the model. It later became evident that the facilitator needed further skills to focus on the transferring the elicited knowledge to other participants by encouraging their participation.</p>
C. Communication	<p>The observation, recordings and notes taken during the KET sessions show that participation was not restricted to experts' contributions. Stakeholders contributed actively to the debates, even when it was only to raise questions and concerns in the search for experts' answers and support.</p> <p>Given the way the exercise was run, some stakeholders were able to challenge the knowledge of experts, which resulted in intense discussions leading to learning by both parties.</p>

B.1. Key ideas and themes from the knowledge elicitation and transfer project at GTM Ltd

IV. Evaluation: Evaluation of the KET technique

The KET exercise was evaluated in two ways:

1. At an organisational level.

A presentation was delivered to a GTM team including managers and some of the participants in the KET exercise, in an attempt to relate CoMEx outcomes to critical success factors for the organisation. As has been shown in other sections of this appendix, management saw the value of the exercise and was willing to take it further.

2. At an individual level: interviews were held on an individual basis six months after the end of the exercise in order to explore potential impacts of the KET project in the way of working of GTM engineers. Six stakeholders argued that they had benefitted from it. One stakeholder had changed his role since the exercise and was not clear about the benefit for its current role.

B.2. Key ideas and themes from the knowledge elicitation and transfer projects at Cranfield University

I. CoMEx approach: The implementation of knowledge elicitation and transfer based on collaborative modelling the PhD research process	
A. Outcomes of the application of CoMEx	<p>The outcomes identified by individuals can be grouped into four main categories:</p> <ol style="list-style-type: none">1. Learning by experts: All experts found it useful to discuss PhD research as process. All but one mentioned that they had only looked at the PhD process by focusing on one specific stage at the time. One expert argued that it had changed her view of the challenges that the PhD research process involved. The following comments have been extracted from the data collected to support these findings: <i>“it did make me re-think the postgraduate process and training issues [...] and also the effectiveness of a structured approach”</i> <i>“it did maybe make me consider the PhD process from a more strategic perspective”</i> <i>“I wasn’t aware of what goes on [in the PhD research process] from the academic point of view and how much students have to achieve by certain dates”</i>2. Learning by stakeholders: Data collected suggest that all stakeholders learned from the academics involved in the KET exercises. The following are examples of such data: <i>“It’s got me thinking about what I need to be doing. I was all the time thinking about the parts of the process rather than the whole picture. I realised how much I know and don’t know about the process, which I find very useful”</i> <i>“It gave me a clear idea of the process. I didn’t have that idea before”</i>3. New explicit resources became available: Four different models of the PhD process were produced. The models were described as useful tool for many purposes (e.g. training, guidance etc) by all individuals. <i>“the courses on research methodologies and research training should use this model”</i>

B.2. Key ideas and themes from the knowledge elicitation and transfer projects at Cranfield University

	<p><i>"I now have a plan and a proper structure. If I follow it, it should be OK for me"</i></p> <p><i>"the model clarifies and extents it [the PhD flowchart provided by the University]. They are developed from different points of view"</i></p> <p><i>"it [the model] says what to do, how to do, and I think it is really useful"</i></p> <p><i>"I would definitely put this [model] up here for reference. What happens day to day may not be represented, but in general it works"</i></p> <p><i>"it [the model] introduces you to the whole PhD process and tells you a plan of how you are going to do it"</i></p> <p>Additionally, over 5 hours of recording of the analysis of the PhD research process by academics became available, which could be used to complement the models produced in the documentation of the PhD research process.</p> <p>4. Expanded new or existing communities</p> <p>The outcomes of one of the KET exercises were presented by the researcher to PhD students in an attempt to share that knowledge with the PhD community. PhD students found it interesting and they were provided with copies of the models produced.</p>
B. Modelling	<p>Four out of the five KET sessions that took place at Cranfield University had modelling as their primary focus. Participants argued that modelling the PhD process had provided significant benefits.</p> <p>1. Modelling the process enabled experts to look at the bigger picture of the PhD research, which all of them but one had never done before. The following comments help understand this point:</p> <p><i>"it [modelling the PhD process] broadens the perception of research by allowing to hear from people that are doing a different type of research"</i></p> <p><i>"[modelling the PhD process] gives people some idea of what they should be doing all the time"</i></p> <p><i>"this [modelling the PhD process] would have helped a new academic who is not experienced in supervising PhD students"</i></p> <p>2. All stakeholders argued that they had learned by modelling the process in collaboration with academics. The following comments have been extracted to support such claim:</p>

B.2. Key ideas and themes from the knowledge elicitation and transfer projects at Cranfield University

	<p><i>“arguing my points of view during the meetings and modelling it cleared up in my head what I thought the process was”</i></p> <p><i>“more useful than any of the existing formal mechanisms [to provide training to new students]”</i></p> <p><i>“it was useful to see that other people had a similar perception [of the PhD process] to mine, leading to an agreed model”</i></p> <p><i>“It was useful because when I did my research many things went wrong. By going through the development of the model I could see what I did wrong in the past”</i></p> <p><i>“it is good to talk to others in my situation and to the experts”</i></p>
C. Participants	<ol style="list-style-type: none"> 1. The selection of participants: <ul style="list-style-type: none"> The researcher approached potential participants based on his experience at Cranfield University, in discussions with his academic supervisor and following the same principles applied by GTM Ltd. These are: <ol style="list-style-type: none"> a. Experts would be academics with substantial experience in supervision of PhD research and staff from the Remote Monitoring Department, also experienced in the formalities of the PhD process. b. Stakeholders would be PhD students from a range of domain areas and across the spectrum of stages in the PhD process. 2. The validity of the selection: <ul style="list-style-type: none"> Data collected and excerpts presented in this appendix suggest that the selection of participants was appropriate for the purpose of the exercise.
D. Type of knowledge	<p>Knowledge related to the requirements, stages and challenges of the PhD process was successfully elicited and transferred by applying CoMEx at Cranfield University.</p>
E. Technologies	<p>Information and communication technologies were only used by the KET facilitator for the purposes of organising the exercises and requesting feedback from participants. Data projectors and a computer were used at some KET sessions to facilitate the display of information already prepared.</p>

B.2. Key ideas and themes from the knowledge elicitation and transfer projects at Cranfield University

II. Other approaches: The limitations of other approaches to KET versus the application of CoMEx	
A. Demands from participants.	The KET exercises at Cranfield University only required participants' response to an initial interview, their presence in the KET sessions and their response to a final questionnaire.
B. Experts	There is no evidence in the data collected to suggest that the KET exercises at Cranfield University were limited by the ability of experts to contribute their knowledge.
C. Motivation	<p>Data collected suggests that both experts and stakeholders were motivated to contribute and learn from others during the exercise.</p> <p>1. Experts:</p> <p>Academics were motivated by the fact that they would be able to provide their views of the PhD research process and it would support PhD students. On completion of the exercises only one of the experts mentioned that he had had a similar type of discussion in the past. All experts found it motivating, would recommend participating in the process to other people, and would discuss PhD research as process again. One expert found it so interesting that she argued that the exercise changed her view of the challenges that the PhD research process involved. The following comments were extracted from the data collected with the aim of supporting those claims:</p> <p><i>"I found the process and discussions very interesting"</i></p> <p><i>"I hadn't understood what goes on from the academic point of view and how much students have to achieve by certain dates"</i></p> <p><i>"I would be delighted to contribute again"</i></p> <p>2. Stakeholders:</p> <p>Prior to the exercise stakeholders found it motivating to talk about PhD research with the academics that were involved, as the following comments suggest:</p> <p><i>"[the project] sounds very useful to me [...] if it's possible I definitely would like to attend"</i></p> <p><i>"[the project] sounds interesting [...] I'll definitely be there"</i></p>

B.2. Key ideas and themes from the knowledge elicitation and transfer projects at Cranfield University

	<p>On completion of the project stakeholders argued that such an opportunity was needed from early stages of their research. The following comments support those claims:</p> <p><i>“it was useful to see that other people had a similar perception [of the PhD process] to mine, leading to an agreed model”</i></p> <p><i>“it is following the model that I have progressed, and being there was very very useful”</i></p> <p><i>“it was quite helpful to see that everyone else was in the same position”</i></p> <p><i>“the exercise was very good and helped put things in perspective”</i></p> <p><i>“I really enjoyed the discussion”</i></p>
<p>III. Group dynamics: CoMEx and the facilitation of group dynamics</p>	
<p>A. Variables affecting individuals’ comfort zones</p>	<p>Although it did not emerge during the data collection, the researcher perceived that an incident that took place during the second exercise had a significant effect in participation, particularly in those people sitting next to the person. The incident raised awareness of the importance of considering the variables affecting individuals’ comfort zones.</p> <p>Data collected in the form of photographs and notes show that following that incident the researcher considered intrapersonal, interpersonal and environmental variables and the solution adopted was incorporated into the definition of CoMEx.</p>
<p>B. The role of the facilitator</p>	<p>Although no direct reference to facilitation was made in the data collection, all participants agreed that the KET sessions could not have been run in a different way. The following comments were extracted from the data in order to support that claim:</p> <p><i>“it was well organised”</i></p> <p><i>“the way we did it was the best to do it”</i></p> <p>Starting from the second exercise the facilitator had a more active role in trying to control the group’s dynamic and enable participation by all group members. This was not successful in the third exercise (see description of the subject <i>Communication</i> below). This suggested the need to focus on the required skills of a facilitator. The issue was addressed and incorporated into the definition of CoMEx.</p>

B.2. Key ideas and themes from the knowledge elicitation and transfer projects at Cranfield University

C. Communication	<p>All participants in exercises I and II had an active role in the communication of their ideas. Experts in exercises I and II only spoke during approximately 50% of the time of the KET sessions. (this figure was produced by analysing samples of the discussions recorded).</p> <p>Although it was not highlighted strong enough by participants in the data collected, the researcher perceived that a problem related to the dynamics of group discussions had a significant effect in participation. The following comments from participants refer to the issue that raised awareness of the importance of issues affecting communication for success of the group exercise:</p> <p style="padding-left: 40px;"><i>“one participant quite strongly imposed his view upon the rest of the team throughout”</i></p> <p style="padding-left: 40px;"><i>“one professor scared the students and was dominant; he was all the time having something to say”</i></p> <p>Data collected in the form of photographs and notes show that these issues were addressed and the solution was incorporated into the definition of CoMEx.</p> <p>There is no evidence in the data collected that suggests that communication-related issues had a negative effect in the success of the exercises following the Cranfield experience.</p>
<p>IV. Evaluation: Evaluation of CoMEx as a KET technique</p> <p>KET exercises at Cranfield University were evaluated in two ways:</p> <ol style="list-style-type: none">3. Immediately after the exercise by asking participants<ol style="list-style-type: none">a. Whether the sessions had had an effect in their understanding of the domain.b. Whether the meetings could have been run in a different way. As in previous exercises some suggestions for improvements were made. However, comments were positive as the examples in this table suggest.4. Six months later<ol style="list-style-type: none">a. By asking participants six months later whether CoMEx had had an effect in the way they deal with issues that they consider critical for the success of their PhD research.	

B.3. Key ideas and themes from the knowledge elicitation and transfer projects at PowerTech UK Ltd

I. CoMEx approach: I. The implementation of the KET exercise based on collaborative modelling the process of handling customer queries	
A. Outcomes of the application of CoMEx	<p>The outcomes identified from the data collected can be grouped into four main categories:</p> <p>5. Learning by experts:</p> <p>All experts mentioned that CoMEx focused their minds on the processes that they normally go through, and also that it made them consider how they operate and what information resources they need and use. Examples of this include:</p> <p><i>“I had forgotten all the processes we have, so the discussions helped as a reminder of them all”.</i></p> <p><i>“It made me consider the way we operate & also ensure that adequate documentation is generated”.</i></p> <p>6. Learning by stakeholders:</p> <p>All stakeholders mentioned that they got to know more ways of handling customer queries and also more information resources. Examples of this include:</p> <p><i>“I expect some improvement in my work”</i></p> <p><i>“The discussions highlighted some other ways of acquiring information that could help me in the future”</i></p> <p>The KM team understood the key issues that were used to define the focus of its work during the following three years. These included the Service engineers’ way of working and their knowledge requirements.</p> <p>7. New explicit resources became available:</p> <p>Several models were produced capturing processes and knowledge management issues relevant to Service engineers at PowerTech UK Ltd. These were in use by the KM team at the time of writing this dissertation.</p> <p>More than three hours of discussion of topics that are key to the success of the company were recorded, where experts’ contribution accounts for more than 80% of the time.</p> <p>8. Communities of interests:</p> <p>Some stakeholders found that knowledge sharing communities were in place in other PowerTech units using</p>

B.3. Key ideas and themes from the knowledge elicitation and transfer projects at PowerTech UK Ltd

	internal facilities such as Lotus Notes Teamrooms. As a result they engaged in collaboration with these virtual communities.
B. Modelling	<p>Participants argued that the models and the explanations during their development helped understand the process of dealing with customer queries and revealed new sources of information available.</p> <p><i>“The process had a good effect in my understanding and it would help if we put more people into this process”.</i></p> <p><i>“After the model [was developed] everything was made clear and everyone seemed to be on the same page”</i></p>
C. Participants	<p>The list of potential participants were provided by the managers of the Service department and Innovation department according to the following principles:</p> <ol style="list-style-type: none"> 3. Experts were Service engineers with significant experience in dealing with customer queries, who had been with PowerTech for 12 years as an average. They were chosen from a list provided by PowerTech UK Ltd middle management. 4. Stakeholders fell into two categories: Junior engineers that needed training and familiarisation with PowerTech ways of working; and members of the KM team who needed familiarisation with the company and also an improved understanding of the areas that required the attention of the KM team.
D. Type of knowledge	<p>Knowledge relating to different aspects of the organisation’s activities was successfully elicited and transferred using CoMEx. These are:</p> <ol style="list-style-type: none"> 3. Process knowledge, related to dealing with customer queries effectively and finding the knowledge needed to achieve that aim. 4. Knowledge about information requirements of Service engineers at work.
E. Technologies	Evidence shows that Information and Communication Technologies were only used by the KET facilitator for the purposes of organising the exercises and requesting feedback from participants.
<p>II. Other approaches: The limitations of other approaches to KET versus the application of CoMEx</p>	

B.3. Key ideas and themes from the knowledge elicitation and transfer projects at PowerTech UK Ltd

A. Demands from participants.	KET exercises at PowerTech UK Ltd only required from participants their response to an initial interview, their presence in the KET sessions and their response to a final questionnaire by e-mail at the time of their convenience.
B. Experts.	<p>Notes taken by the researcher during and after the KET sessions show that:</p> <ol style="list-style-type: none"> 3. The KET sessions took place in a relaxed, informal environment that helped experts to contribute their knowledge however they found it easier to do, e.g. through the use of examples, comparing the limitations of their individual approaches to handling customer queries, etc. <p>An example of this is the following comment from an expert:</p> <p><i>“It was a very relaxing environment; no pressure; nice questions”</i></p> <ol style="list-style-type: none"> 4. There is no evidence that suggests that any of the experts found it difficult to contribute their views on the topics discussed.
C. Motivation	<p>Data collected at PowerTech UK Ltd shows that experts and stakeholders were motivated to actively participate in the exercises for different reasons:</p> <ol style="list-style-type: none"> 3. Experts: The KET facilitator was a member of the KM team and requested their views on the issues that they needed help with. Service engineers rightly felt that their contribution would be made worthwhile by receiving support in the ways they deal with customer queries. The following comments suggest that they were motivated to contribute their knowledge: <ul style="list-style-type: none"> <i>“It is good to have this kind of discussions so that we can learn things that are important for the company, and include people from other departments”</i> <i>“I think it was very fruitful”</i> 4. Stakeholders: In addition to the topic mentioned above, junior engineers were motivated by the fact that they would be discussing their problems with members of the reputable Marine and Offshore Service team, and they would be able to voice their knowledge-related problems to the KM team in the search of their support and guidance. The following comments have been taken as an example: <ul style="list-style-type: none"> <i>“The discussions highlighted some other ways of acquiring information that could help me in the future”</i> <i>“Seems to be a very good model [of the process], may be it needs proper document/template”</i>

B.3. Key ideas and themes from the knowledge elicitation and transfer projects at PowerTech UK Ltd

III. Group dynamics: CoMEx and the facilitation of group dynamics	
A. Variables affecting individuals' comfort zones	<p>Evidence was collected in the form of photographs to show that the researcher sought to consider intrapersonal, interpersonal or environmental variables when organising the exercises.</p> <p>There is no evidence in the data collected that suggests that intrapersonal, interpersonal or environmental variables affected the success of any of the KET exercises at PowerTech UK Ltd.</p>
B. The role of the facilitator	<p>Data collected using different means highlights the following facts related to the facilitation of KET exercises at PowerTech UK Ltd:</p> <ol style="list-style-type: none"> 3. During the running of a KET exercise by a facilitator different from the researcher the following was observed: <ol style="list-style-type: none"> a. A reasonable understanding of the principles of CoMEx was essential for its facilitation. b. The lack of commitment to run all the CoMEx stages had a negative effect in the method achieving its aims. c. Limited application of basic facilitation techniques such as questioning had a significant effect in the success of the KET sessions. d. Despite the difficulties experienced during the running of that particular exercise, feedback received from all participants was positive and did not vary significantly from that received during other KET at PowerTech UK Ltd. 4. The running of the other four KET exercises by the researcher as a facilitator reinforced the validity of the issues a to c above.
C. Communication	<p>The observation, recordings and notes taken during the KET sessions show that participation was not restricted to experts' contributions in any of the five PowerTech exercises. Stakeholders contributed actively to the debates, even when it was only to raise questions and concerns in the search for experts' answers and support.</p>

B.3. Key ideas and themes from the knowledge elicitation and transfer projects at PowerTech UK Ltd

IV. **Evaluation:** Evaluation of CoMEx as a KET technique

KET exercises at PowerTech were evaluated in two ways:

3. Immediately after the exercise by asking participants
 - a. Whether the sessions had had an effect in their understanding of the domain.
 - b. Whether the meetings could have been run in a different way. Some suggestions for improvements were made, though comments were generally positive and ranged from describing the exercise as “very fruitful” to “just about right”
4. Six months later
 - c. By asking participants six months later whether CoMEx had had an effect in the way they deal with issues that they consider critical for the success of their work.
 - d. By analysing the value of the outcomes of CoMEx for the work carried out by the KM team.

The learning from the CoMEx exercise guided the work of the team and presentations given to management during the following year. At the time of writing this dissertation the models were being used as a starting point of the assessment of success of the work that has been completed by the KM team.

B.4. Key ideas and themes from the knowledge elicitation and transfer exercise at MoDInfra

I. **CoMEx approach:** The implementation of knowledge elicitation and transfer based on collaborative modelling the notion of supporting the life of soldiers in the field.

A. Outcomes of the application of CoMEx

The outcomes identified by individuals can be grouped into four main categories:

1. Learning by participants

At an individual level, participants learned about the domain of infrastructure to support life of soldiers in the field and about the skills and experience of team members. The following comments have been extracted from the data collected to support this claim:

“the exercise significantly broadened my understanding of the [MoDInfra] philosophy”

“[the exercise] has made things clearer to me”

At a team level, the exercise helped the team reach a common understanding of what they were to deliver and how. The following comments illustrate this:

“[the exercise] stimulated significant consideration [...] as to what we are looking to deliver and to who”

“The [MoDInfra] team is now on its feet and following the two sessions now in full swing and beginning to leave me behind”

2. Models

The models became useful tools to be used by MoDInfra in the following stage of its programme, as the following comments suggest:

“[the models] have shown areas I feel we are responsible for on one page”

“I have already begun to use the model to assist with the preparation of programme documentation”

“the model could be incorporated into the Quality Strategy Document and is a very useful strategy and reference document”

“[the models] have become useful in measuring actual activity [of MoDInfra]”

B.4. Key ideas and themes from the knowledge elicitation and transfer exercise at MoDInfra

	<p>3. Team building</p> <p>The application of CoMEx supported MoDInfra in their aim to build a team that had a common view of the programme from its early stages and could take it forward. The following comments are included in support of this claim:</p> <p><i>“[the exercise] provided a really good team building platform”</i></p> <p><i>“CoMEx encouraged the team to have a valuable and useful look at what success might be”</i></p> <p><i>“CoMEx provided the team with a conceptual view of success in the models that is already being used to assist with the preparation of programme documentation”</i></p> <p><i>“In many respects the CoMEx philosophy is now embedded within the team’s identity. The team is, therefore, CoMEx works”</i></p>
<p>B. Modelling</p>	<p>The process of developing models describing the scope of the programme and its specific projects brought a number of benefits including the following:</p> <ol style="list-style-type: none"> 1. Four days of discussion leading to agreement in the definitions of key terms such as <i>Infrastructure</i> and topics such as the scope of the program and individuals’ roles and responsibilities. As described by the team leader: <ul style="list-style-type: none"> <i>“[modelling] led the team down a route of ‘question/analyse’, prepare and then deliver which has fitted their preparatory period well”</i> 2. The emergence of new areas where MoDInfra could potentially deliver successful projects, as described by the programme manager: <ul style="list-style-type: none"> <i>“Modelling proved useful in identifying actual activities against which measurement will be carried out, and which may likely further evolve/refine within the models”</i> 3. Finally, the way models were developed suited the expectations of participants, as described by the following comment: <ul style="list-style-type: none"> <i>“excellent modelling work”</i>

B.4. Key ideas and themes from the knowledge elicitation and transfer exercise at MoDInfra

C. Participants	<p>As established in the definition of CoMEx, the organisation was in charge of the selection of participants.</p> <p>Participants were selected by the MoDInfra team leader on the basis that all team members were experts in their domains, had unique skills to contribute to the programme and at the same time would be stakeholders of the knowledge of others.</p>
D. Type of knowledge	<p>Different types of knowledge were elicited and transferred during the MoDInfra exercise. These include:</p> <ol style="list-style-type: none"> 1. Process knowledge related to delivering infrastructure solutions. 2. Project- and programme-related knowledge, in relation to all components of a major programme and their relationships. 3. Individuals' knowledge, in relation to experience of team members and potential contributions to the success of the programme.
E. Technologies	<p>Information and communication technologies were only used by the KET facilitator for the purposes of organising the exercises and requesting feedback from participants. In that sense ICT proved a successful mechanism to support the application of CoMEx, as the facilitator did not have the opportunity to meet the KET team members prior to the first KET session or after the second one.</p> <p>A data projector was also used for the display of information during the KET sessions.</p>
<p>II. Other approaches: The limitations of other approaches to KET versus the application of CoMEx</p> <p>The MoDInfra team leader had successfully led a number of teams before. His background included management training and knowledge about other approaches to knowledge elicitation. His comments suggest that he found CoMEx useful for the purposes of sharing knowledge and building a common understanding of the domain, as shown below:</p> <p><i>“I have seen several programmes start off without such a simple and flexible framework for thinking and without any real idea of the need for knowledge transfer at the start. I would, therefore, suggest that it has put us ahead of the game”</i></p> <p><i>“CoMEx follows a solid sequence of question, analyse, act: intuitively it seems to follow the same broad logic as other models, e.g. antithesis/thesis or the well used/abused OODA loop (Boyd cycle – Observe, Orientate, Decide, Act). Either way it does seem to provide a sound framework for thinking”</i></p>	

B.4. Key ideas and themes from the knowledge elicitation and transfer exercise at MoDInfra

<p><i>"[modelling] led the team down a route of 'question/analyse', prepare and then deliver which has fitted their preparatory period well"</i></p> <p><i>"The team is, therefore the model [CoMEx] works!"</i></p> <p>However, the team leader also made suggestions for improvement of the method, as the following comments extracted from his feedback suggest:</p> <p><i>"The SECI model by Nonaka and Takeuchi has strong parallels with CoMEx. Both encourage knowledge transfer/sharing. Perhaps CoMEx could be developed to reflect the cyclic nature of the SECI model?"</i></p>	
<p>A. Demands from participants</p>	<p>The KET exercise at MoDInfra required from participants their response to an initial questionnaire by email, their active participation in the KET sessions and their response to a final questionnaire.</p> <p>Running the sessions in a remote location was not an imperative. Although it had a cost for MoDInfra, the comments in this appendix suggest that the perceived benefits outweigh the cost of running the exercise at the Defence Academy.</p>
<p>B. Experts</p>	<p>There is no evidence that suggests that any of the experts found it difficult to contribute their views to the exercise.</p> <p>The researcher observed that one of the experts contributed to the discussion less than the rest of the team. However, the MoDInfra team leader mentioned that this was expected given the characteristics of his personality. The same participant, however, made a significant contribution while working in smaller teams during the second part of the exercise.</p>
<p>C. Motivation</p>	<p>Although all participants were required to participate in the KET exercise, there is evidence to suggest that they were motivated to express their views and define their strategy and projects that they would be working on.</p> <ol style="list-style-type: none"> 1. At an organisational level. The following comments along with others already included in this appendix suggest that it was a successful <ul style="list-style-type: none"> <i>"[CoMEx] has put us ahead of the game"</i> <i>"The [MoDInfra] team is now on its feet and following the two sessions now in full swing"</i> <i>"In many respects the CoMEx philosophy is now embedded within the team's identity. The team is, therefore, CoMEx works"</i> 2. At an individual level:

B.4. Key ideas and themes from the knowledge elicitation and transfer exercise at MoDInfra

	<p><i>"I enjoyed the day and it allowed me to understand the Programme better"</i></p> <p><i>"We had a wide ranging discussion"</i></p> <p><i>"[the exercise] has made things clearer to me"</i></p>
<p>III. Group dynamics: CoMEx and the facilitation of group dynamics</p>	
<p>A. Variables affecting individuals' comfort zones</p>	<p>At the time the KET exercises at MoDInfra were run CoMEx had been developed into its fourth version. Such development included considering variables affecting individuals' comfort zones.</p> <p>No data was collected during the MoDInfra exercises that suggest that success of the exercise was limited by intrapersonal, interpersonal or environmental variables.</p>
<p>B. The role of the facilitator</p>	<p>The following comments by one of the participants suggest that the facilitator played an important role in enabling success of the exercise:</p> <p><i>"The presence of interpretive facilitation was a valuable extra factor in helping the team building that is essential at this early stage of the programme"</i></p> <p>Additionally, in this exercise a second facilitator with significant management skills made a major contribution to the running and success of the project. The joint facilitation was not initially planned and was possible after the initial two days of the exercise, when he:</p> <ol style="list-style-type: none"> a. Had gained a reasonable understanding of the principles of CoMEx. b. Was aware of the importance of running all the CoMEx stages.

B.4. Key ideas and themes from the knowledge elicitation and transfer exercise at MoDInfra

C. Communication	<p>The observation and notes taken during the KET sessions show that all participants made, at different stages of the KET exercise, a significant contribution to its success. The following comments, along with some already included in this appendix, support that claim:</p> <p style="text-align: center;"><i>“CoMEx involved all [team members] in an open discussion, exchange of ideas and knowledge transfer”</i></p> <p style="text-align: center;"><i>“We had a wide ranging discussion”</i></p>
<p>IV. Evaluation: Evaluation of the KET technique</p> <p>Success of the implementation of CoMEx at MoDInfra was evaluated at two levels. These were:</p> <ol style="list-style-type: none">1. At an organisational level Identifying during the preparation stage and in collaboration with the management of MoDInfra, the organisation’s critical success factors. Requesting information from the management of MoDInfra with regard to the extent to which the method had helped them in achieving its aim during this stage of their programme and whether its results were likely to help them achieve their critical success factors.2. At an individual level Embedding in the questionnaire used during the post-process review a question aimed at capturing individuals’ immediate reaction to the exercise.	

Appendix C

RELEVANT PAPERS PUBLISHED DURING THE CONDUCT OF THE RESEARCH

The PhD research documented in this thesis started in January 2006, focused on facilitating the elicitation and sharing of knowledge. During its initial stage the author explored the concept of ‘knowledge warehousing’ as a potential approach to KET.

An analysis of the term ‘knowledge warehousing’ found that uses of such a concept in the literature vary from an unnecessary upgrade of the concept of ‘data warehousing’ to an up-market label for traditional KM systems. The results of that study were presented in an international conference and selected for publication in:

GARCIA-PEREZ, A., MITRA, A. 2007. Knowledge warehousing: an appraisal.

In: Stary, C., Barachini, F. and Hawamdeh, S. (Eds). Knowledge Management: Innovation, Technology and Cultures – Selection of papers from the proceedings of the 4th International Conference on Knowledge Management. Series on Innovation and Knowledge Management, 6, 255 – 264. Singapore , World Scientific.

Additionally, a paper reporting what the author understood to be the theoretical foundations of the term ‘knowledge warehousing’ was published in an international journal:

GARCIA-PEREZ, A., MITRA, A. 2008. Revisiting knowledge warehousing:

theoretical foundations. *International Journal of Business Information Systems*, 3, 6, 572 – 586. UK, Inderscience Publishers.

An attempt to give the term ‘knowledge warehousing’ a semantically sound meaning had already been made. The results were also presented in the same international conference:

GARCIA-PEREZ, A., MITRA, A. 2007. A knowledge-based approach to

knowledge warehousing. 4th International Conference on Knowledge Management. Vienna, Austria. August 27 – 28.

Convinced of the complexities of the term 'knowledge warehousing', determined by the nature of knowledge-based resources, the author sought to approach KET from a different perspective. A knowledge elicitation exercise was then run within the research community at Cranfield University.

The method used to identify organisational tacit knowledge resources was outlined in a research paper, along with its validation process. The paper was presented in an international conference:

GARCIA-PEREZ, A., MITRA, A. 2007. A methodological framework to identify and measure tacit knowledge-based resources within organisations. *Proceedings of the 8th European Conference on Knowledge Management*. Barcelona, Spain. September 06 – 07.

A revised version of that paper was selected for publication in an electronic journal the same year:

GARCIA-PEREZ, A., MITRA, A. 2007. Tacit knowledge elicitation and measurement in research organisations: A methodological approach. *Electronic Journal of Knowledge Management*. 5, 4, 373 – 386. Reading, Academic Conferences.

As the author had the opportunity to engage in a collaboration with a gas turbine manufacturer (referred to as GTM in the body of the thesis) from 2007, the new approach to KET was developed. The principles of CoMEx, still in its early stages, were presented in two conferences:

GARCIA-PEREZ, A., AYRES, R. 2008. CoMEx: Facilitating the transfer of knowledge in organisations. *Proceedings of the Conference Exploiting Knowledge and Information in Government*. Defence Academy of the UK. October 1-2.

GARCIA-PEREZ, A., AYRES, R. 2008. Collaborative development of knowledge representations – a novel approach to knowledge elicitation and transfer. *Proceedings of the 9th European Conference on Knowledge Management*. Southampton, UK. September 04 – 05.

One of such papers was selected for publication in an electronic journal. It was revised and published as:

GARCIA-PEREZ, A., AYRES, R. 2009. Collaborative development of knowledge representations – a novel approach to knowledge elicitation and transfer. *Electronic Journal of Knowledge Management*. 7, 1, 55 – 62. Reading, Academic Conferences

In the light of the development and implementations of CoMEx by 2009 and the growth of so-called Web 2.0 technologies, the project previously conducted at Cranfield University was revisited. The authors concluded that although technologies such as Wikis have great potential there are also pitfalls in using these as KET tools which are not yet well understood. This study emphasised the advantages of the approach to KET reported in the thesis over existing technology-based techniques. The results were then presented in an international conference:

GARCIA-PEREZ, A., AYRES, R. 2009. Wikifailure: The limitations of technology for knowledge sharing. *Proceedings of the 10th European Conference on Knowledge Management*. Vicenza, Italy. September 03 – 04

The paper was later selected for publication in an electronic journal:

GARCIA-PEREZ, A., AYRES, R. 2010. Wikifailure: The limitations of technology for knowledge sharing. *Electronic Journal of Knowledge Management*. 8, 1, 43 – 52. Reading, Academic Conferences