Making Knowledge Management in Projects Viable

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Thesis Summary

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Given the increasing prominence of project-based working, it is important for the many organisations that employ them to understand how to get the best out of their project teams. This research assists organisations in doing this by offering help to organisations to improve the effectiveness of knowledge management in their project teams. In order to do this, this research makes a theoretical contribution by extending the viable system model to encompass the project level of organisations, which is then employed to analyse knowledge management at the project level of two organisations. From this analysis, a number of barriers and enablers are identified, which leads to the development of practical advice for organisations to take to improve the effectiveness of their project teams.

Keywords: systems thinking, viable system model, knowledge management, project teams

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Chapter 1

Introduction

Throughout the past fifty years, a gradual change has occurred in the way organisations structure their work. The functional, hierarchical line management paradigm that was so dominant between the late 18th and the mid-20th centuries has been gradually superseded (Turner and Keegan, 1999). Many organisations are becoming increasingly more dependent upon project teams to accomplish tasks (Rubery et al., 2002; Huang and Newell, 2003; Drucker, 1998; Gareis, 1996). This is due to them proving to assist organisations in managing complex tasks (de Meyer, 1998) as well as providing organisations with greater flexibility, in response to the almost constantly changing work environment that organisations find themselves in today (Turner and Keegan, 1999). Given the increasing prominence of project-based working, it is important for the many organisations that employ them to understand how to get the best out of their project teams. The research described in this dissertation aims to assist organisations in doing this.

Before proceeding, the author wishes to define and show the relation between two terms that will be used throughout this research, namely 'project' and 'project team'. Cleland (1999) defines projects, in an organisational context, as discrete entities with delineated start and end points, which aim to deliver a new, or improved, output to meet the operational or strategic responsibilities of an organisation. Examples of outputs that projects may aim to deliver include a new product or service for customers of an organisation, a new factory being built or a new information system being implemented (Mankin et al., 1996). However, the author of this research believes that, just by concentrating on the temporal nature of projects and their outputs, this definition is deficient, as it makes no reference to the resource requirements of projects. Turner (1999, pp. 3) highlights this resource issue in his definition of projects as being:

"an endeavour in which human, financial and material resources are organized in a novel way to undertake a unique scope of work, of given specification, within constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives."

Projects are particularly dependent upon the human resource requirement highlighted by this definition. Many projects carried out in organisations are too complex and large-scale in nature for an individual to complete alone within a reasonable amount of time, requiring a team of individuals to work on them. Ammeter and Dukerich (2002) define a project team as a group of people brought together to complete an assigned task within a certain timeframe before disbanding. For the purposes of this research, the author defines this "assigned task" as being the output of a project described above.

The above definitions show that a project team is a resource that is needed as part of a project. This research focuses on "white collar" project teams, i.e. project teams consisting of members who employ a high level of knowledge in their work as opposed to members who carry out manual labour, and it is these project teams that form the unit of analysis in this research. Many tasks carried out in projects tend to require a considerable level of knowledge, judgement and expertise to be applied by these team members (Cohen and Bailey, 1997). By investigating the knowledge used and shared within project teams, this investigation offers advice to organisations on how to improve the effectiveness of their project teams, through better management of this knowledge.

Project teams also tend to acquire, and draw upon, knowledge from outside their own members (Huber, 1999), as team members may be lacking some of the knowledge needed to complete the project. By investigating the knowledge used and shared between project teams and their external environment (which may include other project teams), this investigation offers further advice to organisations on how to improve their effectiveness at the project level, through better management of this knowledge.

There are two types of knowledge that are used and shared by project teams. One type is known as tacit knowledge, which is defined as knowledge stored in an individual's mind, such as beliefs, paradigms and viewpoints, as well as other know-how and skills that apply to a specific context (Nonaka, 1994). The other type of knowledge is known as explicit knowledge, which consists of articulated, codified and communicated knowledge, which is in natural language or some other symbolic form (Nonaka, 1994). Examples of such explicit knowledge include books, journal articles and reports.

This area of research falls into the knowledge management discipline. This discipline concerns the "*management of knowledge-related activities such as creating, organizing, sharing and using knowledge in order to create value for an organization*" (Wong and Aspinwall, 2004, pp. 93). However, knowledge management is a highly multi-disciplinary area drawing, for example, from the areas of organisational behaviour, social psychology, organisation process and information technology. This research includes discussion on literature taken from all of these areas related by knowledge management.

Systems thinking has been employed in knowledge management research by many authors, e.g. Rubenstein-Montano et al. (2001), Starns and Odom (2006) and Gao et al. (2002), and is used in this research to study the knowledge use of project teams. Systems thinking is an analytical approach that models complex phenomena by breaking them down into a set of interactive parts, and then is used to examine the relationships between these parts (Yolles, 1999; Rubenstein-Montano et al., 2001). The reason a systems thinking approach has been used in this research is that project teams tend to be complex phenomena with a number of members that interact to perform many different tasks. The systems thinking approach provides a tool to manage this complexity (Yolles, 1999), to make it manageable enough for the researcher to analyse. The systems thinking approach is also appropriate as it can handle the human and social aspects of situations (Jackson, 2001), which is crucial to this research, as knowledge sharing is contingent upon human social interaction (Lagerström and Andersson, 2003). A more detailed discussion of the systems thinking approach is given in Section 2.2.
A number of different systems thinking approaches have been developed, such as soft systems methodology, general systems theory, socio-technical systems thinking and

viable system modelling (Flood and Jackson, 1991). However, viable system modelling (VSM) has been chosen as the modelling technique to use for the analysis in this research. The VSM is discussed in much greater detail in Section 2.4 and the reasons for selecting this modelling technique, as opposed to the others available, are presented in Section 3.5.

After an extensive sweep of the literature using EBSCO, Proquest, JSTOR and Science Direct, as well as in edited books, some empirical research was found on the VSM being applied at industry level (e.g. Shaw et al. (2004) and Britton and McCallion (1989)) and the organisational level (e.g. Brocklesby and Cummings (1996), Espejo (1989) and Holmberg (1989)). However, no empirical research was identified to have been carried out at the project level of an organisation. Given the suitability of the VSM to be applicable to the project level (as discussed in Section 3.5), this research fills this gap in the literature. In order to do this, this research will answer the following research question:

- *How can knowledge be managed to help the project level of organisations be more effective in terms of the VSM?*

Through answering this research question, this research makes two contributions. Firstly, a practical contribution is made in that the research provides advice on how knowledge at the project level of organisations should be managed, in order to make project teams more effective. Secondly, the research provides a theoretical contribution of enriching our current understanding of the VSM, by extending the VSM to encompass the project level of organisations.

Chapter 2

General Literature Review

2.1 Introduction

This chapter is structured as follows. First, it provides a detailed description of the VSM and its theoretical foundations. The chapter then discusses the aspects of knowledge management within the VSM, before examining where the VSM has been applied generally in empirical investigations to date. The chapter then finally details work that has been carried out on knowledge management in team settings.

2.2 Systems Thinking

The development of systems thinking was inspired by biology in the 1940s, in response to the inadequacy of the previous mechanistic paradigm for modelling the complexity of biological organisms (Yolles, 1999). The mechanistic paradigm was reductionist, breaking phenomena down into its constituent elements and studying these elements individually to understand the whole (Spruill et al., 2001). However, it was realised that complex phenomena have "*emergent properties that cannot be explained, or even predicted, by studying their individual parts*" (van Regenmortel, 2004, pp. 1016). This realisation was based on the notion that the whole was greater than the sum of the parts. An example of mechanistic thinking, in management terms, is to think of an organisation with a traditional functional hierarchy. Mechanists would believe that each function within this organisation could be independently optimised to achieve some goal (Flood and Jackson, 1991). However, this reductionist approach of the mechanistic paradigm was found to be deficient, with organisations that had each of their functions optimised independently, failing to perform well as a whole (Flood and Jackson, 1991).

It is because of these deficiencies that systems thinking was first developed in biology. In this approach, organisms were treated as whole entities known as "systems", which had emergent properties that did not derive solely from their parts (Flood and Jackson, 1991). Systems thinking also allowed for the organisms to be studied in relation to their interactions with their environments. These features aided the study of complex biological phenomena and it was not long before systems thinking was applied to studies of other types of "system", such as organisations (Flood and Jackson, 1991). The belief that social systems could be analysed this way was based on the "*intuitive similarity between the organization of the human body and the kinds of organizations men create*" (Back, 1971, pp. 660). However, this analogy between organisms and social systems is not without its criticisms. Back (1971, pp. 660) asserts that "*in the development of scientific sociology, grand developmental theories treating society like an organism have become extremely suspect*". Katz and Kahn (1978) criticise this type of thinking, believing that essential differences are ignored between socially contrived social systems, which tend to be characterised by being highly variable and loosely articulated, and the physical structure of human organisms. Due to this, Kast and Rosenzweig (1972) warn that it is probably best not to make the analogy between social systems and biology too literal, agreeing with Silverman (1971, pp. 31) who states that "*it may, therefore, be necessary to drop the analogy between an organisation and an organism: organisations may be systems but not necessarily* ***natural*** *systems*".

Despite these criticisms, the advantages of systems thinking over the previous paradigms led to it being successfully applied in management research (Yolles, 1999). Since its conception, many different systems thinking approaches have been developed which fall into either "hard" or "soft" systems thinking categories. "Hard" systems thinking is concerned with applying systematically ordered thinking to problems that are well structured and have desirable outcomes which can be defined (Checkland, 1983). Such hard systems thinking includes systems engineering, systems analysis and operational research. "Soft" systems thinking, in contrast, is concerned with attempting to impose a level of organisation to a complex, ill-defined situation involving human beings (Checkland and Scholes, 1999). Such systems thinking includes soft systems methodology, general systems theory and socio-technical systems thinking. However, such categorisation of systems thinking approaches is not quite so clear-cut. Whilst some systems thinking approaches can be found at the extremes of being categorised as either hard (e.g. operational research methods) or soft (e.g. soft systems methodology), some also fall in between these two extremes. One of these is viable system modelling which, given its realist epistemology (Jackson, 2000) as discussed in Section 3.2, is applicable to instances that have desirable outcomes that can be defined, as in hard systems thinking, and is also able to deal with the complexity of human subjectivity in problems, as in soft systems thinking.

Systems thinking requires that a "system" is identified prior to analysis. A "system" contains a set of richly interactive connected elements, which are delineated by a boundary from elements where few/weak interactions occur (Flood and Jackson, 1991). The set of richly interactive connected elements is known as the "system domain" and the set of elements where few/weak interactions occur is called the "external environment" (Yolles, 1999). The system takes inputs from this external environment and the elements in the system domain apply processes, which transform the input into outputs for the external environment. These inputs can be physical or abstract in nature, such as raw materials, people, equipment, information or energy, and outputs can also be physical or abstract in nature, such as products or services (Yolles, 1999). Figure 1 shows a diagrammatic representation of a "system":

A General Representation of a "System"

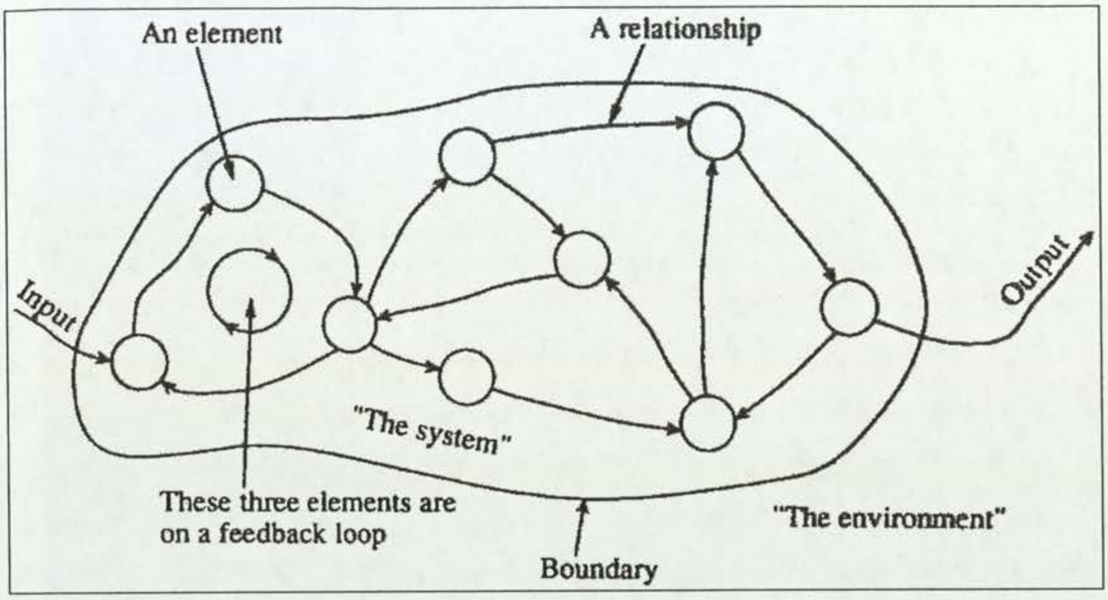

Figure 1 (Source: Flood and Jackson, 1991, pp. 6)

As can be seen from Figure 1, a boundary has been set around the "system" to define it from its external environment. Inputs are taken from the external environment and go through a number of processes carried out by the elements before being output back into the environment. One of the features of the system depicted in Figure 1 is the use of feedback. Feedback is the information that informs the corrective action needed to be taken if the output of an element, such as in terms of volume and quality, does not meet performance targets set by process managers (Gill, 2002). In this case, feedback is sent to the element that initiated the behaviour, either directly or through a chain of elements, in order to influence the future behaviour of the initiating element (Flood and Jackson, 1991). This feedback mechanism forms part of the communication and control processes of the field of cybernetics, which is now discussed below.

2.3 Cybernetics

Cybernetics is a field that studies how information and control actions are used in complex systems to steer them towards meeting their objectives, whilst counteracting various disturbances (Heylighen and Joslyn, 2001). Cybernetic theory can be applied to understand, model and design any type of system, such as technological, biological or social systems (Heylighen and Joslyn, 2001). Applied to the study of management systems, cybernetics is defined as the "*science of effective organisation*" (Beer, 1979, pp. 4). This field of managerial cybernetics follows the principals of systems thinking, described above (Yolles, 1999).

Cybernetics provides the tool of a "black box" approach to analyse elements in a system. This approach prevents analysts from having to become too "bogged down" with the complexity of all the tasks that elements perform in a system, in order to transform their inputs into outputs. Figure 2 shows how this approach models an element:

The "Black Box" Approach of Analysis

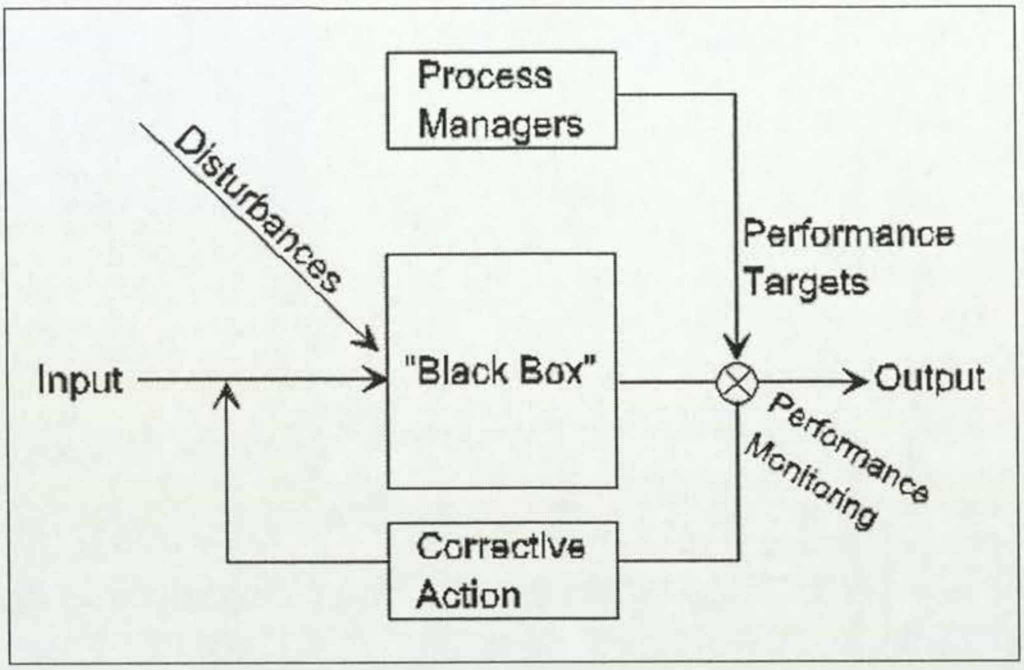

Figure 2 (Source: Gill, 2002, pp. 1)

As can be seen from Figure 2, performance targets are set by process managers and then compared to the actual output of the system element. If required, corrective action (informed by feedback from the performance monitoring process) can then be taken to adjust the inputs, so that the outputs can better meet the targets set (Gill, 2002). Figure 2 also shows that disturbances can occur, which can have an impact on the output of the element. Such disturbances include the variability of inputs, competitor actions, industrial action or external environment disturbances (Gill, 2002). Such disturbances can be caused by the "variety" of the external environment and need to be managed to ensure that outputs from the element continue to meet the performance targets set. It is this "variety" that the Law of Requisite Variety proposed by Ashby (1956) seeks to describe in management cybernetics.

The Law of Requisite Variety defines the "*general conditions of adaptiveness of a system to the range of variability of its environment*" (François, 1999, pp. 210). In order to control this environmental variability, Ashby (1956, pp. 207) states that only "*variety* *can destroy variety*". This "variety" is a measure of complexity, defined by the number of possible states a system can take (Heylighen and Joslyn, 2001). Intuitively, it follows that variety is significantly greater in the external environment than within an organisation, leading to a natural imbalance (Espejo and Gill, 1997). In work on the Law of Requisite Variety, it was shown that when variety in the external environment is greater than the variety within the internal set of responses of a system, the control mechanisms of a system will not always be able to optimally respond to stimuli in the environment (Gray, 2000). For this reason, Beer (1974) believes that systems should absorb environmental variety by increasing (amplifying) their own variety, or by reducing (attenuating) the variety incoming from the external environment. An example of this process between an organisation and its external environment is shown in Figure 3:

Methods of Absorbing Environmental Variety

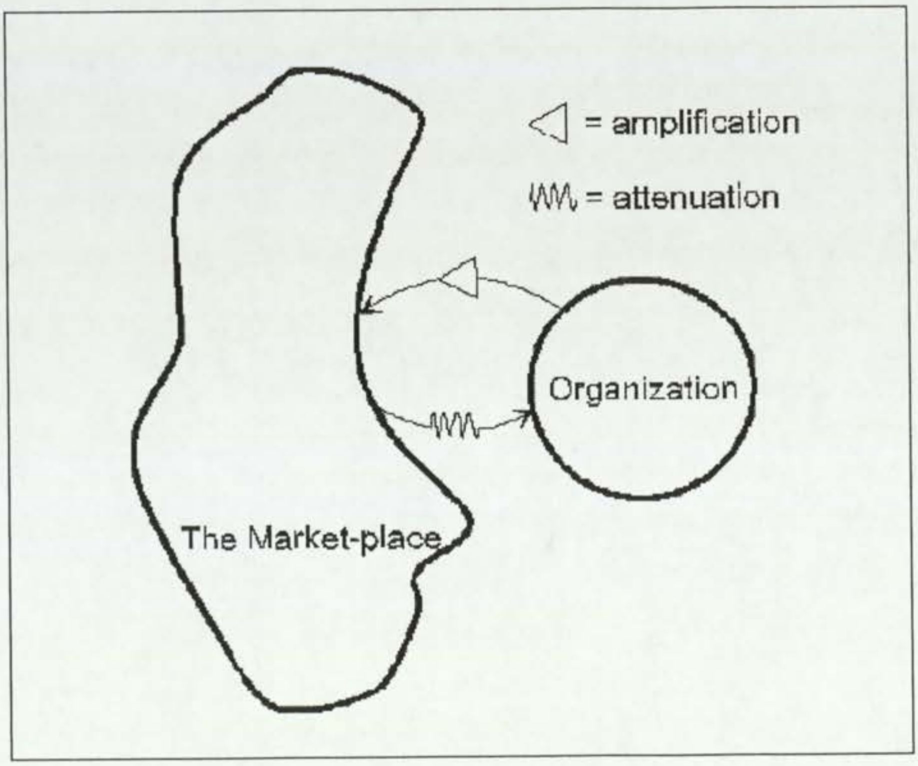

Figure 3 (Adapted From: Gill, 2002, pp. 3)

An example of amplification in Figure 3 would be an organisation, facing changes through globalisation, to respond by increasing its variety through accessing new resources and capabilities (Devine, 2005). The organisation could also attenuate this variety from globalisation by persuading the Government to put trade barriers in place (Devine, 2005). Once there is a balance between the variety of the system and its external environment, this is defined as "requisite variety" (Leonard, 1999).

Another important concept in cybernetics is autopoiesis, which means "*self-producing*" (Mingers, 1995, pp. 11). Beer (1979, pp. 405) uses this idea in managerial cybernetics to define an autopoietic system as a system that continuously "*produces itself*", that is to say that an autopoietic system "*goes on*" and is able to retain its identity over time, regardless of the changes made within the system itself. These changes can include staff coming and going or departments opening and closing, but an autopoietic system is able to maintain its identity despite these events occurring (Beer, 1979). For example, a bank can change its structure by closing all of its high street branches and offering its services instead through online banking, telephone banking and cash machines and still be identifiable as a bank, since it will still be providing financial services (Vidgen, 1998). Beer (1979) provides further examples of autopoietic systems, including Oxford University, the steel industry and Britain, which have all undergone changes over time but are all still recognisable as themselves.

Cybernetic thinking is at the heart of the viable system model, which is discussed below.

2.4 Viable System Model

Developed by Beer (1979, 1981, 1985), the viable system model (VSM) is a modelling technique that is one of the systems thinking approaches discussed in Section 2.2. The model is built upon the Law of Requisite Variety, described above, with systems needing to handle the variety in their environments in order to remain "viable".

"Viability" is described as the ability of a system to be autopoietic and maintain a separate existence and survive on its own (Beer, 1979). In order to achieve this viability, a system needs to be able to adapt itself, either incrementally (morphogenesis) or dramatically (metamorphosis), in order to manage the variety of the external environment (Yolles, 2000). The VSM also specifies that five key systems (henceforth labelled S1 to S5) also need to be in place within a viable system for this viability to be achieved (Espejo and Gill, 1997). The viability of a system is said to inevitably be prejudiced if this structure is not completely adhered to (Schwaninger, 2006). However, Jackson (1988) notes that social systems can still exist and perform well when not adhering to the structure of the VSM. For this reason, optimal viability can be achieved through the structure of VSM, but certain systems with sub-optimal viability will still be able to exist. The five key systems of the VSM are:

- S1 - Implementation
- S2 - Co-ordination
- S3 - Control
- S4 - Intelligence
- S5 - Policy

A diagrammatic representation of the VSM is shown in Figure 4:

The Viable System Model (VSM)

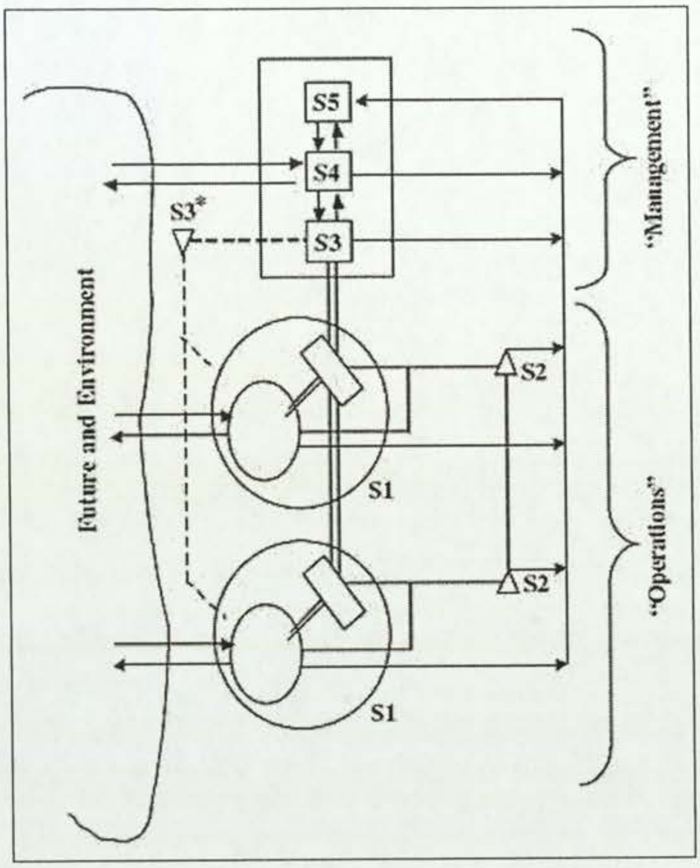

Figure 4 (Adapted From: Shaw et al., 2004, pp. 272)

As shown by Figure 4, S1 and S2 are classed as being part of "operations" and S3, S4 and S5 are concerned with "management". Before going into deeper detail about what each system does, it is important to note that, whilst these systems are numbered 1-5 and are represented with S5 at the top and S1 at the bottom in Figure 4, the VSM treats S1, S2, S3, S4 and S5 with equal importance (Brocklesby et al., 1995). It is also important to note that it is rare that a person would be part of only one of the systems 1-5 in an organisational viable system, as they are likely to play multiple roles within the viable system (Leonard, 1999). These two concepts allow the VSM to break away from viewing systems in terms of traditional hierarchical relationships, allowing it to concentrate more on the resources and relationships needed to maintain the viability of a system (Espejo et al., 1999).

A description of these five key systems will now be given using, and building on, the school teaching system example presented by Beer (1979). In this example, the system will be defined as the school teaching system, which encompasses the teaching staff, school teaching facilities and resources, as well as the management of the teaching activities within the system. Students are classed in this example as the customers of the school teaching system. The purpose of the school teaching system is to educate these students.

S1 consists of the operational elements that carry out the primary activities needed for the system to accomplish its purpose (Björkqvist, 1996). Each operational element consists of the operation and its localised management that carries out the operation, as shown in Figure 5:

An S1 Operational Element in the VSM

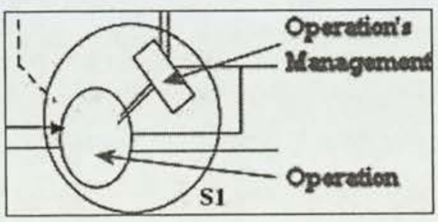

Figure 5 (Adapted From: Shaw et al., 2004, pp. 272)

An important requirement of the VSM is that these operational elements are given, within the constraints of the purposes of the system, as much autonomy as possible to absorb as much of the variety from the external environment as possible (Jackson, 1988). Through interacting directly with the external environment, S1 elements have the greatest understanding of it and so should be allowed to interact freely with it to reduce the variety that S2-S5 need to deal with (Brocklesby et al., 1995). By giving S1 elements a high level of autonomy, it gives them the best opportunity to match the variety of its customers in the external environment to the products and services it produces (Leonard, 1999). In the school teaching system example, S1 contains student classes as operational elements. Each class is the responsibility of a teacher, with the intention (output) of learning maximisation for the students within the class.

S2 coordinates the primary activities of S1 and dampens oscillations between them (Leonard, 1999). Oscillations are the variance from the overall purpose of the system caused by the behaviour of S1 elements getting in each other's way. An example of oscillation would be one S1 element withholding access to a resource when the shared use of it would me more beneficial to the whole system (Brocklesby et al., 1995). It effectively ensures the operations management elements are carried out within the system. In the school teaching system example, many of the facilities of the school are shared. For example, the laboratories and sports facilities can only be used by a certain number of student classes at a time. In order to co-ordinate the teaching activities in these facilities, a school timetable is used to ensure that only one lesson is taught in one room to a class at any single point in time.

S3 entails the day-to-day management control system, which monitors and maintains the efficiency of the operations in S1 (Björkqvist, 1996). S3 also decides what the distribution of resources should be amongst the S1 operations (Leonard, 1999). In the school teaching system example, S3 would set goals for student attainment by a certain period. Through the use of student examinations, this attainment can then be monitored as a measure of the performance of teaching staff. S3 would also engage in resource bargains for textbooks, educational software, etc. with the teachers responsible for the classes.

S3 also has a special function that lets it monitor the relations between itself and S1, known as S3* (Leonard, 1999). S3* provides an audit facility which allows management to delve into the detail of the operations in S1, to ascertain specific information on a sporadic basis (Leonard and Bradshaw, 1993). In the school teaching system example, an assessor may be used to sit in during one of the lessons a teacher gives to their class, or a sample of student exam papers may be marked by a second examiner to ensure exams are being marked correctly.

S4 encompasses all of the functions that look into the future (Leonard, 1999) to allow the development of strategic options for the system to adapt to its future environment (Devine, 2005). Examples of this would be the market research and the research and development functions of an organisation (Leonard and Bradshaw, 1993). In the school teaching system example, information on new subjects that could be taught and updates for existing lesson syllabi would be gathered.

S5 includes the policy-making functions that set the values, purpose and the overall direction of the system (Espejo and Gill, 1997). In the school teaching system example, decisions such as whether the school should take on a specialist status, for example becoming an art school, are made. A decision to become an art school gives the school teaching system the values, purpose and the overall direction of teaching art subjects to its students.

Beer (1981) states that, for a system to be viable, it must be autopoietic in its totality and in S1 only. He warns that a system becomes pathologically autopoietic if it develops autopoiesis in S2, S3, S3*, S4 or S5 and this will threaten its viability. Therefore, S2, S3, S3*, S4 and S5 must not try to create an identity for themselves, instead they must be seen as support functions which serve the productive units in S1, which are what give the system as a whole an identity (Flood and Jackson, 1991; Vidgen, 1998).

A feature of the VSM is recursion, which stipulates that each viable system is "*embedded in other more comprehensive systems*" (Leonard, 2000, pp. 711). For example, individual workers might be embedded in a work group, which is embedded in a department, which itself is embedded in an organisation, which in turn is embedded in an industry. It should be noted here that, whilst recursion in this sense is hierarchical, the VSM emphasises that this does not imply that this hierarchy is the structure of authority in a system (Leonard, 2000). The different levels of recursion are assigned numerical identifiers, with the system being analysed (henceforth called the system-in-focus) being at recursion level 1. The system that the system-in-focus is embedded in is at recursion level 0 and the systems that are embedded within the system-in-focus are at recursion level 2. In the example given above, if a department is defined as the system-in-focus then it is at recursion level 1. This then leads to the organisation the department is in being at recursion level 0 and the work groups that make up the department being at recursion level 2. Incrementally higher or lower levels of recursion are assigned incrementally higher or lower numerical identifiers. Continuing the example above, this means that the industry the organisation is in would be defined as recursion level -1 and the individual workers that make up the work groups would be at recursion level 3. Whilst some recursive relationships are neatly nested, others may have fluctuating boundaries and be embedded in a range of recursive relationships (Leonard, 1999). For example, an organisation may be embedded in a number of different industries. It may also be the case that individuals within an organisational viable system will perform different roles at different levels of recursion (Leonard, 1999). Recursion allows a viable system to be analysed in its context, enabling the analyst to have an integrated understanding about the situation (Yolles, 1999).

Whilst the VSM is generally held in high regard by the management science community, it is not without its criticisms. One such criticism is that the VSM is too simplistic to study organisational systems (Rivett, 1977; Checkland, 1980), as it is based on organismic analogy and misses the conscious and reflective elements that Dachler (1984) believes are present in social systems. However, Jackson (1988) disagrees with this criticism, arguing that the VSM has enormous explanatory power compared to other organisational analysis tools because it is underpinned by cybernetic science. Jackson (1988) does, however, criticise the VSM for focusing on the structure of organisational systems without taking into account the cultural aspects of them as well. Leonard (1999) does not concur with this, though, as she sees S5 as the part of the VSM that handles the cultural aspects of an organisational system. Culture is seen to form part of the identity of the system and is an important attenuator of variety to allow the system to disregard ill-fitting future directions early on (Leonard, 2000). It should also be noted that, as with any systems thinking approach, no two-dimensional diagrammatic representation of phenomena can ever fully capture the multidimensional complexity of reality (Brocklesby et al., 1995). However, as long as the VSM is used with this in mind, it provides a highly useful tool to assist in analysis.

Having discussed the main features of the VSM and the functions that S1, S2, S3, S3*, S4 and S5 perform, the next section will discuss how these different systems interact within a viable system.

2.5 Knowledge Management in the VSM

As shown by Figure 4, S1, S2, S3, S3*, S4 and S5 interact in certain ways with each other. All of these interactions within a viable system include communications and knowledge flows (Hoverstadt and Bowling, 2005), which are shown as links in Figure 4. This section describes the literature on the types of knowledge needed and their flows between S1, S2, S3, S3*, S4 and S5. As stated by Achterbergh and Vriens (2002, pp. 224) "*knowledge is a critical factor for maintaining organizational viability*". This knowledge is important as it is used to dampen variety in organisational viable systems. It does this by providing the framework for individuals and organisations to choose alternatives from amongst the extensive range of possibilities available to the system (Leonard, 1999).

The knowledge that each of S1, S2, S3, S3*, S4 and S5 require and the knowledge that flows between them will now be described with reference to the literature that discusses knowledge management in terms of the VSM.

Achterbergh and Vriens (2002) established the concept of organisational viability being attributable to knowledge and then presented the types of knowledge needed to achieve this. This article also shows the dependencies between the different systems of the VSM in terms of the knowledge they use. The knowledge that these authors highlight is very much focussed on goal setting and measures to overcome gaps between actual results and the desired goals. This article highlights how important cybernetic information and control actions were to the development of the VSM. Leonard (1999) and Leonard (2000) focus less on the knowledge required for control actions and more on the knowledge used to carry out the tasks performed by each system in the VSM. It is through the synthesis of the different perspectives of these three articles that has led to the development of Tables 1-6 below, which show the knowledge that each of S1, S2, S3, S3*, S4 and S5 require and the knowledge that flows between them. de Raadt (1990), with his focus on knowledge transmission during adaptation, and Yang and Yen (2007), with their focus on input, process and output knowledge at a much more abstract level than the other articles, were also used to supplement the development of Tables 1-6 below.

Table 1 shows the types of knowledge required and shared by S1 in the VSM. Please note that each type of knowledge is labelled in the corresponding brackets for ease of reference in this research:

Knowledge Required and Shared by S1 in the VSM

System	Types of Knowledge Required/Shared
Environment → S1	• knowledge required to perform each primary activity (*A1) • input knowledge for each primary activity (*A2) • knowledge of customers (*A3)
Environment ← S1	• output knowledge from each primary activity (*A4)
S1	• how to perform each primary activity (*A5)
S1 ← S2	• how to implement counteractions for oscillation (*A6) • informal control procedures (*A7)
S1 ← S3 (via S2)	• how to counter actual performance and performance goal misalignment (*A8) • resource allocation (*A9) • implementation plans for innovation/new legal requirements (*A10)

Table 1

S1 performs the primary activities of the system and therefore needs to contain the knowledge needed to perform each primary activity. Weick (1969) believes that, in order to be viable, systems need to possess a certain amount of knowledge at their inception. This knowledge (*A5) will reside within S1, either tacitly from the actors within it, in the form of knowledge of the processes used to perform the primary activities, or explicitly in the form of step-by-step procedure documents, copyrights, patents and trademarks, etc. (Leonard, 2000). If knowledge on how to perform a primary activity, or part of it, does not already reside in S1, it can be sourced from the external environment (*A1) via the connection between S1 and the external environment in Figure 4. This type of knowledge can be tacit and come from outside experts (Leonard, 1999), such as that sourced from consultants, specialists, etc. However, some knowledge may be explicit, such as that sourced from training course documentation, libraries, journals, etc. Knowledge of how to perform each activity may be shared between different primary activities in S1, as shown by the link between different S1 primary activities in Figure 4. Different primary activities may have similar processes, customers or technology and so may be able to learn from one another (Leonard, 1999). S1 primary activities may be able to recognise the potential for collaboration themselves or be given direction by S2 (*A6). If knowledge is needed as an input (*A2), or is an output (*A4) of a primary activity, this will also be shared between S1 and the external environment. An example of output knowledge (*A4) would be teachers, in the school teaching system example of Section 2.4, whose students were in the external environment, transferring educational knowledge to their students, in order for the primary activity (teaching) to occur. Knowledge of customers (*A3), such as the current state of the market, customer preferences, demographic information, etc., is also very important for S1 to obtain (Leonard, 1999). This knowledge is key to the relationship the organisation has with its customers, helping to retain current customers by being able to understand their current wants and needs. S1 will also need to be informed by S2 how to counteract oscillations (*A6) when S2 finds these instances have occurred. Informal control knowledge (*A7), such as attitudes to safety, how things are generally done within the operations side of the business and confidentiality issues, is also provided from S2 to S1 (Leonard, 2000). S1 also needs to know how to counter any misalignment between actual performance and the performance goals set by S3 (*A8). S3 also informs S1 of the resource allocations for conducting the primary activities (*A9) and any plans for new innovation implementations/new legal requirements (*A10).

Table 2 shows the types of knowledge required and shared by S2 in the VSM:

Knowledge Required and Shared by S2 in the VSM

System	Types of Knowledge Required/Shared
S1 → S2	• what interdependencies exist between the primary activities in S1 (*B1) • performance loss due to actual oscillations (*B2) • causes of oscillations (*B3)
S2	• difference between actual and permitted level of performance loss due to oscillations (*B4) • the measures available to counter the difference between actual and permitted level of performance loss due to oscillations (*B5) • operational knowledge (*B6)
S2 ← S3	• permitted level of performance loss due to oscillation (*B7)

Table 2

S2 dampens oscillations between the primary activities in S1 and co-ordinates them so that synergy can be achieved. In order to investigate oscillation, S2 first needs to ascertain information from S1 relating to the performance loss from oscillation (*B2) and then establish the level that S3 will permit of performance loss due to oscillation (*B7). Once S2 has established these figures, it can determine whether the level of oscillation is higher than the permitted level allowed by S3 (*B4). If it is, then knowledge of what measures are available to dampen oscillation (*B5) are needed, so that appropriate dampening measures can then be selected based on the interdependencies of the primary activities (*B1) and the causes of the oscillations (*B3). S1 is then informed of the measures selected and how to implement them (*A7). Operational knowledge (*B6), which tends to be explicit knowledge, such as patent expiry dates, schedules, maintenance records, project reports and personnel records of operational staff, is also held within S2 (Leonard, 2000). S2 also acts as the bridge between the "operations" and "management" domains in Figure 4. A vast amount of knowledge resides within S1, which would be impossible for "management" to fully comprehend (Leonard, 1999). S2 acts as a filter for "management" so that they only receive the knowledge that is necessary for them to carry out their tasks. This concept is based upon the "black box" approach described in Section 2.3.

Table 3 shows the types of knowledge required and shared by S3 in the VSM:

Knowledge Required and Shared by S3 in the VSM

System	Types of Knowledge Required/Shared
S1 → S3 (via S2)	• actual performance of each primary activity (*C1) • causes of any failure of each primary activity to achieve its goals (*C2) • resource requirements of primary activities (*C3)
S2 → S3	• synergies between the primary activities (*C4)
S3 → S3*	• audit results (*C5)
S3	• performance goals for each primary activity (*C6) • actual performance and performance goal misalignment (*C7) • the measures available to counter the difference between actual performance and performance goal misalignment (*C8) • management accounting information (*C9) • whether innovation proposals meet overall system goals (*C10) • difference between requirements of primary activities to implement innovation proposals and current capabilities of S1 (*C11)
S3 ← S4	• innovation proposals (*C12) • legal requirements (*C13)
S3 ← S5 (via S4)	• overall system goals (*C14)

Table 3

S3 provides the link between the operations and management domains, as shown by Figure 4, so that it can monitor and maintain the operational elements of the system. To do this, it sets performance goals for the primary activities of S1 (*C6). It compares these goals to the actual performance of S1 primary activities (*C1) to calculate the misalignment between these (*C7). Knowledge of what measures are available to correct this misalignment are needed (*C8), so that appropriate correction measures can then be selected, based on the causes of any failure of each primary activity to achieve its goals (*C2). Audit results (*C5) from S3* are also used to ensure S1 performance reports are accurate. S3 also decides the resource allocation, using management accounting information contained within S3 (*C9), for each primary activity (*A9), by considering the requirements of each primary activity (*C3). Resource allocations also use knowledge provided by S2 of the synergies between the primary activities (*C4), so that resources can be allocated in such a way as to gain the highest performance of the whole system (Leonard, 2000). The resource bargaining often takes place in real-time, with adjustments being constantly made to changing conditions (Leonard, 1999). Whilst explicit knowledge from management accounting (*C4) and performance figures (*C1) are used, it is the tacit knowledge about how people work together and the work that they perform, provided by S2 as the synergies between the primary activities (*C4), that is the most important aspect of resource allocation activities (Leonard, 2000). The performance goals, oscillation goals and the resource allocation set by S3 attenuate the variety of the S1 operational elements. It sets boundaries for S1, which substantially narrow the variety available to the operational elements (Leonard, 1999). S3 also considers innovation proposals (*C12) from S4 and checks whether they meet overall system goals (*C10) sourced from S5 via S4 (*C14). These innovation proposals are further checked to see what extra requirements would be needed to implement the innovations compared to current capabilities (*C11). S3 also deals with new legal requirements (*C13) observed by S4, such as health and safety regulations, new patent violations, etc., so that it can create and implement plans for S1 to meet new legal requirements (*A10).

Table 4 shows the types of knowledge required and shared by S3* in the VSM:

Knowledge Required and Shared by S3* in the VSM

System	Types of Knowledge Required/Shared
*S1 → S3**	• knowledge required for audit (*D1)
*S3**	• how to conduct an audit (*D2)
S3 ← S3*	• requirements of the audit (*D3)

Table 4

The sole purpose of S3* is to conduct audits on behalf of S3. S3* will be given the requirements of the audit (*D3) by S3 and will then obtain the knowledge required (*D3) from S1, such as quality control procedures, information technology usage, financial information and safety standards, etc. (Leonard, 1999). S3* decides on what knowledge and whose perspectives need to be sought (*D2) to carry out the audit (Leonard, 2000). S3* may use a range of investigative techniques, such as looking at documentation, direct examination, creation of models/simulations, interviews and measurement to carry out the audit, which also must be chosen (*D2) by S3* to use for the audit (Leonard, 2000). Auditing intellectual capital is one of the challenges S3* faces. Whilst explicit knowledge, such as patents, are relatively easy to identify, tacit knowledge in the form of employee skills and capabilities are much more difficult to identify. For this reason, S3* tends to investigate processes of control rather than specific knowledge transactions when auditing intellectual capital, such as whether the S1 infrastructure supports adequate communication between primary activities or whether there are systems in place to quickly locate an employee with a specific skill required (Leonard, 1999). Once the audit has been completed, S3* will report the findings (*C5) back to S3.

Table 5 shows the types of knowledge required and shared by S4 in the VSM:

Knowledge Required and Shared by S4 in the VSM

System	Types of Knowledge Required/Shared
S3 → S4	• review of innovation proposals (*E1)
Environment → S4	• relevant developments in the external environment (*E2)
Environment ← S4	• manipulation of external environment (*E3)
S4	• what is relevant for innovation proposals (*E4)
S4 ← S5	• overall goals (*E5)

Table 5

Organisational systems are adaptive systems and need to be able to change goals to maintain viability (Achterbergh and Vriens, 2002). S4 is responsible for this by looking for developments in the external environment (*E2) that could be relevant to the system, so that it can suggest the future direction for the system. S4 carries out a number of activities to achieve this, including market research, R&D, conference attendance and extensive reading of literature (Leonard, 1999; Leonard, 2000). Conversations between people within the system and the customers and suppliers in the external environment are also hugely important for S4 to be able to sense emerging market needs and trends (Leonard, 1999). As the external environment has an infinite number of states, the relevance of developments is important to the system, as S4 needs to filter the variety of the environment in its innovation proposals (*C13). Whilst innovations may be in the form of new products that an organisational system could produce, employee training or recruitment proposals may also be made by S4 (Leonard, 1999; Leonard, 2000). However, it is also important that S4 does not filter the information from the environment too much, as new developments that are not obviously relevant to the system may offer a desirable new direction for the system. S4 therefore needs to be able to make a decision (*E4) about how much information it filters, by considering the developments in the external environment (*E2) in conjunction with the organisational goals (*E5) provided by S5. Once these innovation proposals have been considered by S3, it sends a review (*E1) back to S4. S4 can also try to influence the external environment (*E3) to change it in ways to benefit the system (Jackson, 1988). An example of such a manipulation would be to use advertisements to try to change customer desires to that of products a system produces. This manipulation can, however, sometimes be dangerous as it may lead to the damage of relationships that the system depends upon in the external environment (Morgan, 1982).

Table 6 shows the types of knowledge required and shared by S5 in the VSM:

Knowledge Required and Shared by S5 in the VSM

System	Types of Knowledge Required/Shared
S1, S2, S3, S4 → S5	• algedonic signal (*F1)
S3 & S4 → S5 (via S4)	• innovation proposals by S4 and their reviews by S3 (*F2) • the level of imbalance between S3 and S4 (*F3) • causes of the imbalance between S3 and S4 (*F4)
S5	• how to counter the imbalance between S3 and S4 (*F5) • plans for system goals adaptation (to take in account of the innovations from S3 and S4) (*F6) • values, purpose and the goals of the system (*F7)

Table 6

S5 sets the values, purpose and the goals of the system (*F7). This identity that S5 provides the system with is an important attenuator of variety, as it determines what is relevant to the system and what is irrelevant, which provides a focus so that the system can follow a direction (Leonard, 1999). The knowledge used to set this identity is mainly tacit but some explicit knowledge may also be used, such as in the form of self-assessment exercises (Leonard, 2000). S5 looks at innovation proposals and their reviews (*F2) provided by S3 and S4, and makes a final decision on how to proceed through adapting system goals (*F6). An important aspect of the VSM is that it pays particular attention to the knowledge flows between S3 and S4. Tension naturally arises between S3 and S4, due to the desire of S3 for stability and the desire of S4 for adaptation (Jackson, 1988). This tension is controlled by S5 through the S3/S4 homeostat, which is used to maintain the balance between the present activities of the system, with those activities that are oriented towards the future (Leonard, 1999). S5 finds out the level of imbalance between S3 and S4 (*F3) and the causes of it (*F4), if any. S5 should regularly monitor this balance, as it tends to fluctuate over time (Leonard, 1999). If there is an imbalance present, S5 needs to know how to counter the imbalance between S3 and S4 (*F5). If this balancing of S3 and S4 does not take place, the system can run into two difficulties. One difficulty occurs when S3 is "stronger" than S4, which leads the system to continue with its current activities, despite relevant environmental developments that the system needs to adapt to (Achterbergh and Vriens, 2002). The other difficulty occurs when S3 is "weaker" than S4, which leads the system to implement new innovations, without having the required operational capabilities to successfully carry them out (Achterbergh and Vriens, 2002). One of the methods that can be used to improve the balance between S3 and S4 is to tightly couple the two systems through allocating S3 and S4 responsibilities and activities to a single team (Achterbergh and Vriens, 2002). Where this method is impractical, for example when S3 and S4 responsibilities and activities are too large to be handled by a single team, frequent communication between S3 and S4, as well as other opportunities for the two systems to become familiar with the perspectives of each other, must take place to ensure the balance is maintained (Leonard, 1999). Beer (1994) developed a process called Team Syntegrity that can facilitate knowledge exchange between S3 and S4.

This process allows non-hierarchical communication to occur between participants to develop synergy and integrate multiple perspectives (Schwaninger, 2004; Leonard, 1999). As shown by the connection between S5 and all of the other systems in Figure 4, the VSM provides a special function called the algedonic signal (*F1), which allows any part of the system to alert S5 to a threat or opportunity that impacts on the whole system (Leonard, 1999). The fact that this signal bypasses the other systems in order to reach S5 shows the need for rapid response, and it is comparable to the reflex reactions of a person who touches a hot stove (Leonard, 1999).

In order to aid cross-referencing, Tables 1-6 have been combined to form Table 7:

Knowledge Required and Shared in the VSM

System	Types of Knowledge Required/Shared
Environment → S1	• knowledge required to perform each primary activity (*A1) • input knowledge for each primary activity (*A2) • knowledge of customers (*A3)
Environment ← S1	• output knowledge from each primary activity (*A4)
S1	• how to perform each primary activity (*A5)
S1 ← S2	• how to implement counteractions for oscillation (*A6) • informal control procedures (*A7)
S1 ← S3 (via S2)	• how to counter actual performance and performance goal misalignment (*A8) • resource allocation (*A9) • implementation plans for innovation/new legal requirements (*A10)
S1 → S2	• what interdependencies exist between the primary activities in S1 (*B1) • performance loss due to actual oscillations (*B2) • causes of oscillations (*B3)
S2	• difference between actual and permitted level of performance loss due to oscillations (*B4) • the measures available to counter the difference between actual and permitted level of performance loss due to oscillations (*B5) • operational knowledge (*B6)
S2 ← S3	• permitted level of performance loss due to oscillation (*B7)
S1 → S3 (via S2)	• actual performance of each primary activity (*C1) • causes of any failure of each primary activity to achieve its goals (*C2) • resource requirements of primary activities (*C3)
S2 → S3	• synergies between the primary activities (*C4)
S3 → S3*	• audit results (*C5)
S3	• performance goals for each primary activity (*C6)

	• actual performance and performance goal misalignment (*C7) • the measures available to counter the difference between actual performance and performance goal misalignment (*C8) • management accounting information (*C9) • whether innovation proposals meet overall system goals (*C10) • difference between requirements of primary activities to implement innovation proposals and current capabilities of S1 (*C11)
S3 ← S4	• innovation proposals (*C12) • legal requirements (*C13)
S3 ← S5 (via S4)	• overall system goals (*C14)
*S1 → S3**	• knowledge required for audit (*D1)
*S3**	• how to conduct an audit (*D2)
S3 ← S3*	• requirements of the audit (*D3)
S3 → S4	• review of innovation proposals (*E1)
Environment → S4	• relevant developments in the external environment (*E2)
Environment ← S4	• manipulation of external environment (*E3)
S4	• what is relevant for innovation proposals (*E4)
S4 ← S5	• overall goals (*E5)
S1, S2, S3, S4 → S5	• algedonic signal (*F1)
S3 & S4 → S5 (via S4)	• innovation proposals by S4 and their reviews by S3 (*F2) • the level of imbalance between S3 and S4 (*F3) • causes of the imbalance between S3 and S4 (*F4)
S5	• how to counter the imbalance between S3 and S4 (*F5) • plans for system goals adaptation (to take in account of the innovations from S3 and S4) (*F6) • values, purpose and the goals of the system (*F7)

Table 7

The discussion of the literature so far has been of a highly theoretical nature. The next section will discuss a range of the empirical investigations that have been carried out using the VSM.

2.6 VSM Applications

The VSM has been applied in two different ways in the literature. One application is to use the VSM as a design template to build a cybernetically-sound system from scratch (Brocklesby et al., 1995). The other, much more common, application of the VSM has been to use it as an analysis tool to identify the cybernetic strengths and weaknesses of a system to diagnose problems (Brocklesby et al., 1995). Table 8 summarises a range of the empirical work that has been carried out using the VSM:

Previous Empirical Studies using the VSM

Author(s)	System(s) Analysed
Beer (1979)	Organisation (Life Insurance Company)
Beer (1981)	Government (National)
Ben-Eli (1989)	Organisation (Medical Centre)
Britton and McCallion (1989)	Network (Trade Training)
Brocklesby and Cummings (1996)	Organisation (Telecommunications Company)
Espejo (1989)	Organisation (Manufacturing Company)
Holmberg (1989)	Organisation (Paper and Packaging Company)
Schwaninger (2006)	5 Organisations (Insurance Company, Media Company, Chemical Corporation, Health Service Company and Energy Production Corporation)
Shaw, Snowdon, Holland, Kawalek, and Warboys (2004)	Network (Electricity Market)

Table 8

With the exception of Holmberg (1989) and some of the case studies in Schwaninger (2006), all of the articles in Table 8 used the VSM as a diagnostic tool, to identify cybernetic weaknesses within the system analysed. The reason that the VSM appears to be rarely used as a tool to design a system from "scratch" is that it is only really feasible to do in two situations. Systems either need to have leaders who believe systems must constantly re-invent themselves to stay ahead of the competition, or it is applicable for systems "*for whom a major shake-up is the last hope of survival*" (Brocklesby and Cummings, 1996, pp. 56). However, Brocklesby and Cummings (1996) suggest that neither of these situations occur very often. This can be due to leaders not identifying that a major shake-up is necessary early enough, or from them believing that they can turn the situation around without the help of such a tool. However, one situation where the VSM has been used for organisational re-design is reported by Holmberg (1989). In this article, the VSM was turned to as the organisation began to struggle severely. The organisation took the approach of educating its employees in the VSM to change the culture within the system over a five-year period. Through gradually accepting the principles of, and using, the VSM structure, the organisation is reported to have become profitable once more. Schwaninger (2006) also reports on one system (an insurance company) partially implementing the VSM for a major re-invention of itself. The company fully re-structured their basic business units to match the "operations" (S1 and S2) structure of the VSM. This was classed as a major success for the company, allowing them to build upon a firm foundation for the future.

Table 8 also shows that the majority of applications of the VSM have been to organisations. These organisations all differ in size and are based in a range of industries, showing the versatility of the VSM in organisational analysis. The VSM was also applied in Beer (1981) to a national government, and in Britton and McCallion (1989) and Shaw et al. (2004) to analyse networks, which again shows that the VSM can be used to analyse a range of different situations. However, the VSM has never previously been reported to have been applied to analyse the project level of an organisation. This is the gap in the literature that this research seeks to fill. Whilst the VSM has never previously been reported to have been applied to study the project level, literature does exist on knowledge sharing at this level. This literature is reviewed in the next section.

2.7 Project Teams

Two distinct areas of knowledge management in project teams exist in the literature, one of these is knowledge management *within* project teams and the other is knowledge management *between* project teams. In terms of knowledge management *within* project teams, the use of teams provides a mechanism to pool together, and then apply, the diverse knowledge of employees (Drucker, 1994). This mechanism is often enhanced by organisations through allocating members from different functional units in their project teams. This allows specialised expertise to be pooled from different functional units to accomplish complex tasks which could not be dealt with easily by a single unit (Davidow and Malone, 1992). Fong (2003, pp. 483) supports this point in his study of knowledge sharing in cross-functional project teams, by finding it "*to be an advantage to have a diverse pool of knowledge for team members to access and share in discussion*". The use of cross-functional members allows project teams to access knowledge that might otherwise be concealed by functional boundaries (Henke et al., 1993).

However, Fong (2003, pp. 483) also warns that, in order for sharing of knowledge to occur in cross-functional teams, a process of "*boundary crossing*" has to be completed first. Cross-functional teams consist of members from a range of professions (Carrillo et al., 2004) each embedded within different functional units. These functional units often utilise certain processes and practices that are specific to them (Nicholas, 2001), which tends to lead to function-specific subcultures forming within organisations (Schein, 1996). Due to project team members coming from these different subcultures, they have different expertise and use different terminology, which can lead to misunderstandings occurring if technical jargon is used in communication between members (Pincus, 1997). Therefore, knowledge has to be shared to other members in such a way that non-experts can understand it.

The sharing of knowledge is highly dependent upon the relationship between the sender and the receiver of knowledge (Prencipe and Tell, 2001), with knowledge sharing occurring less when this relationship is not close (Goh, 2002). von Krogh (1998) supports this point, emphasising that the level of trust between team members will have an impact on the level of their knowledge sharing. Fernie et al. (2003) suggest that effective knowledge sharing depends on building trusting relationships with people over long periods of time. Additionally, it has been pointed out by Nicholas (2001) that it is difficult for people to build up trust over a short period of time. This point is particularly relevant to project teams, which are characterised by finite timeframes, which can lead to little trust being built up, even by the time a project has been completed (Koskinen et al., 2003; Pretorius and Steyn, 2005; Bresnen et al., 2003).

At a fundamental level, trust is based on how well team members believe each other to have the ability to absorb and retain the knowledge being transferred to them (Zárraga and Bonache, 2003). Fong (2003) also suggests that the boundary crossing barrier identified above is overcome through generating trust, with project team members valuing the expertise of the other members. However, trust is particularly based upon the perceptions of team members of the intentions of their fellow members. For example, if team members suspect that another member is engaging in politics by withholding information to increase their power in the team/organisation, it is much less likely that the other team members will share knowledge that could make that member even more powerful. In order to encourage a high level of trust, Goh (2002) suggests that decisions should be made openly and members should be treated fairly, with rewards given to all of those who contribute to shared success. Stewart (2001) further suggests that, to develop trust between members, they should be given time to become acquainted with one another.

Fong (2003) also identified that there needs to be a motivating factor in order for knowledge sharing to occur within project teams. Goh (2002) highlights this as a particular problem, as it is often the case that there are no visible rewards for sharing knowledge. Pretorius and Steyn (2005) suggest that performance appraisals should include elements looking at the level of participation in knowledge management activities by team members, to motivate them to share knowledge.

Fong (2003) also identified that time pressure may result in knowledge not being shared effectively within project teams. Due to the tight schedules usually inherent in projects, it often leaves members so occupied with completing their tasks that they may not have the time to engage in knowledge sharing activities (Purvis and McCray, 1999; Carrillo et al., 2004; Kasvi et al., 2003). For this reason, it is suggested that employees need to have time explicitly made available for them to carry out knowledge sharing activities (Goh, 2002; Garvin, 1993).

Knowledge sharing can occur in two different ways within project teams. One of these is through the use of technology and, in modern organisations, information technology has been identified as, perhaps, the most effective method of facilitating knowledge transfer (Karlsen and Gottschalk, 2004). E-mail is particularly relied upon to facilitate knowledge sharing in organisations, although other technologies such as instant messaging and the telephone are also used. The advantage of using technology is that it can connect people regardless of whether they are in different locations. In the case of e-mail, it also means that knowledge sharing does not need to occur in real-time, by allowing the recipient to receive the knowledge when they next log onto their e-mail account. However, information technology is not necessarily the most effective method of sharing knowledge, with Pretorius and Steyn (2005) pointing out that e-mail, in particular, struggles to cope when lots of detail is necessary (as it takes a long time to write and read) or when the knowledge is confidential (as emails provide a record of the knowledge that has been shared, which could fall into the wrong hands). Lagerström and Andersson (2003), in their study on how knowledge is shared within a transnational team, identified that information technology is not sufficient on its own for high quality knowledge sharing to occur. These authors found that information technology was important for sharing updates and support for the day-to-day work of the team, but was insufficient for sharing detailed knowledge. Lagerström and Andersson (2003, pp. 94) found that knowledge sharing is "*contingent upon sufficient amounts, and quality, of social interaction*" between team members, whereas information technology plays a subordinate role. Both Pretorius and Steyn (2005) and Fong (2003) support this finding, especially for tacit knowledge, with Fong (2003, pp. 483) stating in his research that within a project team for "*tacit knowledge to be effectively transmitted, interpersonal communication seemed of the utmost importance*".

In terms of the sharing of knowledge through social interaction, it can occur through both formal and informal methods (Holtham and Courtney 1998). Formal methods include meetings and training sessions (Alavi and Leidner, 2001), as well as participative workshops (Fernie et al., 2003). Lagerström and Andersson (2003) note that meetings facilitate efficient communication and interaction to engage in knowledge sharing. In particular, these authors noted that knowledge sharing was further enhanced when these meetings were regular. Informal methods of knowledge sharing include unscheduled meetings, informal seminars (Holtham and Courtney 1998) and the so-called 'water-cooler effect' (Gorlenko, 2005). This water-cooler effect suggests that people share a lot of tacit knowledge between themselves when doing non-job specific activities, such as getting a drink of water, going on a coffee break, etc. These informal methods require team members to be in close proximity to one another to facilitate knowledge sharing (Stewart, 2001).

The process of sharing knowledge through social interaction has been identified by Lagerström and Andersson (2003) to assist in the boundary crossing process described above. These authors identified that social interaction increases levels of both mutual understanding and trust between members in a team, leading to a higher propensity amongst them to share knowledge. These authors also identified that the value of information technology for knowledge sharing increases once the team members have initially engaged in social interaction and gained an understanding about each other's competencies and interests.

Another important enabler, in terms of the type of knowledge required, for project teams, is the setting of performance goals. Lynn et al. (1999) stress the importance of the practice of setting goals, as it facilitates performance in individuals and groups. Performance needs to be measured against these goals to ensure that they are being met, with corrective actions being taken if they are not (Turner, 1999). The literature makes a distinction between two types of goals that should be set. One of these is a vision, which is an overall goal that provides a focus for effort, motivating a direction to be taken to achieve the goal (Lynn et al., 1999). The other type of goal is interim goals that, once they are all achieved, lead to the attainment of the overall goal. Research suggests that setting goals has a positive effect on performance at the individual level, with individuals that are set specific goals tending to outperform those without (Locke et al., 1981). As well as at the individual level, goal setting has also been shown to increase performance at the team level. Larson and LaFasto (1989) attribute the presence of an overall goal as a feature of a well functioning team and O'Leary-Kelly et al. (1994) found that higher performance was attributed to clear and specific goals being set for teams. Lynn et al. (1999) found that it was most effective for project teams when both the vision and interim goals set were clear, stable and supported by enough resources to make them achievable. In particular, these authors emphasise the importance of keeping the goals stable for project teams, as modifications to the vision or interim goals can increase both the cost and duration of the project dramatically. However, Koskela and Howell (2002) suggest that a complete and up-to-date project plan is impossible to maintain during the course of a project in reality, leading Turner (1999) to state that plans need to change over time in a project, i.e. goals cannot remain static during the lifetime of projects.

Huang and Newell (2003) also identified that steering groups are sometimes used by project teams in order to control and monitor progress. Kasvi et al. (2003) put forward a model of an organisation which uses a steering group to form and maintain a plan for a project team. In this model, the steering group updates the project plan by adjusting the goals during the project lifetime.

In terms of knowledge management *between* project teams, effective knowledge sharing between projects can aid them by using ideas and experiences developed in one project to solve the problems of another (Hargadon and Sutton, 1997; Goodman and Darr, 1998; Davies and Brady, 2000). Knowledge sharing between project teams occurs in one of two ways. It can either refer to a project team sharing knowledge with other concurrent project teams, or knowledge being stored for use in projects that will occur in the future (Fong, 2003). In sharing knowledge between concurrent project teams, knowledge is transferred before all of the tasks are completed in a project (Fong, 2003). In storing knowledge for future projects, the tasks of a project are completed before storing the knowledge for use in subsequent projects (Fong, 2003). In both cases, the usefulness of knowledge sharing between project teams requires a certain degree of similarity between the projects, either in terms of their tasks or their principals (Fong, 2003). However, Boh (2007) suggests an issue here is that, due to the nature of projects being highly customised, they tend to differ from each other in many critical aspects.

In knowledge sharing between concurrent projects, Fong (2003) found in his research that the most widely used strategy was to allocate project team members to work on multiple projects at the same time. He found that this was much more common than generating explicit knowledge to share with other concurrent project teams.

Pretotrius and Steyn (2005, pp. 47) found that projects in organisations tend to be "*managed as separate entities and little contact exists between different project managers or different project teams*". In order to increase the level of knowledge sharing between projects, Carrillo et al. (2004) believe that it is essential to specifically employ someone and give them responsibility for knowledge management in project environments. Pretorius and Steyn (2005) support this notion, suggesting that a specific person should be made responsible for knowledge management between projects. Newell et al. (2006) found that intermediaries overseeing many projects are able to identify where knowledge acquired by one project team could be useful for another project team. Scarborough et al. (2004) found in their research that, providing there is some commonality between the projects, through explicitly linking projects together it greatly enhances the foundation for knowledge sharing across projects.

One of the barriers to knowledge being stored for use in projects that will occur in the future is that, once a project has been completed, the project team members have a natural incentive to get on with their next project, rather than dwell on the issues of the completed project (Cooper et al., 2002).

As with knowledge sharing *within* project teams, sharing knowledge *between* project teams can be carried out either through the use of technology or through social interaction. Prencipe and Tell (2001) state that a knowledge repository of lessons leant can be maintained to store knowledge for access by other project teams. These knowledge repositories are typically computerised, allowing explicit knowledge in the form of documents to be searched (Newell et al., 2006). In terms of social interaction, Prencipe and Tell (2001) state that meetings can be held between project teams to share knowledge. Another social interaction method which can be used to enable knowledge sharing to occur between project teams is to transfer one project team member to another project team (Huber, 1999), either during concurrent projects or after their project has been completed.

As with knowledge sharing within project teams, Pretorius and Steyn (2005) identify that a low level of trust between project teams, resulting from limited social interaction, is a barrier to them sharing knowledge. These authors concentrate on the managers of each project specifically in their study, but believe that by having regular review meetings between different project teams, and also increasing the level of informal social interaction between them, helps to overcome this barrier. These authors also suggest that knowledge sharing activities between different project teams should form part of the performance appraisal of each project manager, to get them to motivate knowledge sharing between project teams.

Time is also an issue, with Newell et al. (2006) suggesting that project team members may not have time to search for whether their required knowledge exists in a knowledge repository or input it themselves, for example. Bresnen et al. (2003) highlight this by showing that people are more likely to use the telephone to contact someone they know, who they believe will be able to help, rather than consult a computerised system. Another factor that Bresnen et al. (2003) found to be a barrier to project team members consulting a computerised system was that the knowledge it contained was often out-of-date, as there were no incentives or resources provided to keep it up-to-date.

2.8 Summary

In summary, the VSM is a modelling technique based on a systems thinking approach. It has strong cybernetic foundations, which make it a powerful explanatory tool that can be used to analyse and diagnose viable systems. The VSM models a number of interactions, which results in the need for certain knowledge to be shared within a system. The VSM has been applied to a range of different situations, but has never previously been reported to have been applied to the project level of an organisation.

Whilst the VSM has never been reported to have been applied to study the project level, literature does exist on knowledge sharing at this level. This literature includes studies on knowledge sharing both *within* project teams and *between* project teams. It has been identified that knowledge sharing can occur either through technology or through social interaction. Barriers to knowledge sharing *within* project teams were identified as including: different cultures/language of members, a low level of trust between members, poor motivation and time pressure. It was also identified that project goals should be identified to give project teams direction. Knowledge sharing *between* project teams can happen either concurrently or after a project has been completed. Barriers to knowledge sharing between project teams were identified as including: poor linkage of similar projects, natural incentives for members to move on to the next project rather than dwell on the issues of the completed one, a low level of trust between project teams, low motivation to share knowledge between project teams and a lack of time.

Chapter 3

Methodology

3.1 Introduction

This chapter first describes the philosophical underpinnings of the research method. It then describes how and what data was collected, before finally detailing the techniques used to analyse the data and the limitations of these techniques.

3.2 Philosophical Underpinnings

This research sought to describe and explain the knowledge usage and sharing processes of project teams in an organisational context, rather than to test hypotheses. These descriptions and explanations are derived from a phenomenological standpoint, with the researcher studying the social world of the project teams in the organisation, where humans have the ability to think, form opinions and comprehend their own behaviour (Shaw, 1999). The phenomenological standpoint is appropriate as the research aims to study the phenomenon in its natural setting.

The research is conducted within the realism paradigm. The ontological aspect of this paradigm stipulates that realism is the belief that an objective "real world" exists, although it is only imperfectly apprehensible (Healy and Perry, 2000). This ontology lies closely to the way multiple data collection types have been used in this research to allow the examination of how the reality is apprehended by different sources. Epistemologically, realism research studies participant perceptions in order to "*provide a window on to a reality beyond those perceptions*" (Healy and Perry, 2000, pp. 120). This approach to researching perceptions is taken in this research, which seeks to discover how the reality of the sharing of knowledge in the project teams was seen by participants. It is argued that the type of question this research attempts to answer is also consistent with the realism paradigm. Research which tries to answer "*how and why?*" questions tend to fall within the realism paradigm (Perry, 2001). As stated in Chapter 1, this research attempts to answer *how* knowledge can be managed to help the project level of organisations be more effective in terms of the VSM.

The conduct of this research within the realism paradigm is consistent with the literature in the team knowledge research field. In an attempt to identify the dominant paradigm in team knowledge research prior to conducting this research investigation, a comparison of twelve articles from the field was undertaken to give a general indication of the dominant paradigm. Literature was identified from the team knowledge research field using EBSCO, Proquest, JSTOR and Science Direct. Articles were chosen to reflect the broad range of areas in this field that the researcher determined to be relevant to this research, namely: intra-team knowledge management, inter-team knowledge management, team learning, cross-functional/cultural team knowledge management and barriers to/enablers of team knowledge creation and sharing. Articles relevant to these categories were identified by their title and, from this sample, eight articles (i.e. two thirds of the twelve articles required) were chosen that were classified as being from journals ranked as World Leading/Internationally Excellent by Aston Business School (2006). This was done to reflect the dominant research paradigm present in the highest standard of work in the field. The other third of the twelve articles (i.e. four articles) were chosen that were from national based publications in order to give an appreciation of whether there was any difference in the dominant research paradigm in the lower ranked work in the field. Whilst it is accepted that this sample does not form a systematic literature review of the dominant paradigm in team knowledge research, to do so would have been too large a study to have carried out for this dissertation. Due to this, it is acknowledged that the sample of articles selected is just a general indication of the dominant paradigm. A description of the research paradigms and methodologies of the twelve articles selected is given in Table 9:

Research Paradigms and Methodologies of Previous Team Knowledge Research

Author(s)	Research Paradigm	Methodology
Edmondson, Bohmer and Pisano (2001)	Realism	Multiple case study design (16 cases): • Interviews • Observations • Documentation analysis
Fong (2003)	Realism	Multiple case study design (2 cases): • Interviews • Observations • Documentation analysis
Huang and Newell (2003)	Realism	Multiple case study design (4 cases): • Interviews • Observations • Informal dialogues • Documentation analysis
Lagerström and Andersson (2003)	Realism	Single case study design: • Interviews • Documentation analysis
Lynn, Skov and Abel (1999)	Positivism	Survey method
Newell, Bresnen, Edelman, Scarbrough and Swan (2006)	Realism	Multiple case study design (6 cases): • Interviews • Documentation analysis
Prencipe and Tell (2001)	Realism	Multiple case study design (6 cases): • Interviews
Pretorious and Steyn (2005)	Realism	Single case study design: • Interviews • Observations • Documentation analysis
Scarbrough, Bresnen, Edelman, Laurent, Newell and Swan (2004)	Realism	Single case study design: • Interviews • Documentation analysis
Styhre, Roth and Ingelgård (2002)	Realism	Single case study design: • Interviews • Observations
Warkentin, Sayeed and Hightower (1997)	Positivism	Experiment method
Zárraga and Bonache (2003)	Positivism	Survey method

Table 9

Table 9 shows that realism is the dominant paradigm within this sample. The ontological aspect of this paradigm, which was described above, lies closely to the way data has been collected for many of the articles within this research area. Eight of the realism articles identified in Table 9 triangulate data such as archival records, interviews and observation to examine the different apprehensions of reality and check for cases of consistency and discrepancy.

Despite realism being shown to be the dominant paradigm, some research was conducted from a positivist standpoint. Positivism tends to be concerned with theory testing, through the use of hypotheses verification (Healy and Perry, 2000), rather than with the building of theory generally associated with the realism paradigm. The ontological aspect of the positivist paradigm stipulates that reality is real and apprehensible (Guba and Lincoln, 1994). Epistemologically, positivism assumes that the researcher and item of study are independent, suggesting that the researcher can carry out the investigation without influencing it or being influenced by it (Guba and Lincoln, 1994). Three articles were identified in Table 9 as being within this paradigm. Lynn et al. (1999) seem particularly successful in taking this approach and used a survey method to investigate practices in team learning and their impact on product development. This is a completely different focus to the realism articles in Table 9, which are more concerned with how knowledge is created and shared in teams, rather than the impact it has. By investigating the impact, it allowed the researchers to define objective measures of success, i.e. speed to market and new product success. In contrast, the other two positivist studies focused more on the knowledge itself, rather than its impact. However, a truly positivist approach, which ignores subjective data, does not seem applicable to these two articles. As an example, Zárraga and Bonache (2003) used the survey method in order to investigate the extent to which the creation and transfer of knowledge occurred in work teams. However, these researchers measured the *perception* of the participants, as they conceded that there was no objective data available to indicate the degree of the creation and transfer of knowledge in the teams. This lack of objective data is one of the reasons that the dominant paradigm within the sample of articles is not positivism.

Shaw (1999) believes that positivism is inadequate for studying the social world, as it needs to be observed in its totality rather than just being reduced to isolated variables. For example, Newell et al. (2006, pp. 170) aimed to "*understand the processes by* *which project-based knowledge and learning are created and transferred*". As these processes were embedded in group culture within the social world of the organisation, it would be infeasible to separate these processes from their social context. This argument is also applicable to the research described in this dissertation, as it is the *social system* of project teams that is being studied. For this reason, the author rejected taking a positivist approach as it was felt it was not applicable for this study.

As stated above, the realism paradigm is consistent with building theory. For this reason, an inductive analysis approach was carried out on the data, which uses the observations derived from the data to build towards general patterns (Patton, 2002). A deductive analysis approach was not used, as it was considered too difficult to make hypotheses about the data prior to analysis. The inductive analysis used theoretical sampling for data collection and sampling. Theoretical sampling specifies that sampling of participants, episodes and interactions must be driven by the theory as it emerges, rather than by a desire to generalise (Miles and Huberman, 1994). Due to the sampling being driven by the theory as it emerges, there is a need for data collection and analysis to occur simultaneously (Miller and Brewer, 2003). This iterative process of collecting and analysing data simultaneously allows the researcher to reflect on the entire research process throughout the study and refine it accordingly (Flick, 2006). This reflection and refinement process was important for this research, as it allowed the researcher to focus subsequent data collections on the aspects of knowledge sharing that appeared the most pertinent. Therefore, the data for this research was collected and analysed simultaneously, with data being transcribed and analysed soon after each time it was collected.

Analysis of the data was conducted in the context of the VSM. As common to all systems thinking approaches, a "system" is merely a metaphor for a situation. This metaphor may allow inquirers to better understand a situation, but it is important to remember that the situation is not really a "system", and so the model created by an inquirer may break down (Yolles, 1999). It should also be noted that, as a "system" is created by an individual, its nature will vary depending on the purpose of the inquirer and their world view (Yolles, 1999). This is in keeping with the realism paradigm described above, as a "system" is an inquirer's apprehension of reality (i.e. the situation) constructed as a model.

3.3 Data Collection

As supported by Table 9, the dominant approach taken in the literature to investigate questions similar to this research is to use qualitative methods through a case study design approach. For example, Lagerström and Andersson (2003) studied knowledge sharing in transnational teams by basing their study exclusively around a single case study of a multinational corporation. As further examples, Huang and Newell (2003) used four case studies in researching the knowledge integration processes within cross-functional projects, and Fong (2003) used two case studies in investigating knowledge creation processes in multidisciplinary project teams. Each of the authors of these articles chose to use a case study approach in order to gain an overall detailed account of the social world that they were investigating. The research in this dissertation followed such authors so that, through the use of a case study approach, the research would retain the "*holistic and meaningful characteristics of real-life events*" (Yin, 2003, pp. 2) that occurred during the time the project teams were studied. Retention of this level of detail was important for this research, as it allowed a rich description of the phenomenon to be created, through which an explanation could be formed (Hamel et al., 1993). It is this explanatory element that was crucial to the research, as the main aspiration of it was to generate theory about project team knowledge sharing. The suitability of the case study approach to enable this is supported by Yin (2003), who argues that explanatory studies which try to answer "how" questions, such as that posed by this research, are likely to prefer the use of case studies as a research strategy.

In order to gain a detailed account of the social world that they were studying, the majority of authors in Table 9 used qualitative research methods. Shaw (1999) believes that the social world authors such as these investigated should not be reduced to the isolated variables that quantitative research methods require. Qualitative research methods, in contrast, allow variables to be identified, but not disembodied, from the connections they have with other variables in the social world (Miles and Huberman, 1994). For this reason, it is argued here that the qualitative approach taken in this research was the most appropriate, in order to investigate the social world of the research problem.

As knowledge sharing occurs over time, a longitudinal study was conducted that followed the project teams during the ten month period from when they were first formed. Research using just a single instance in time through a cross-sectional approach may not have captured the richness of data in terms of the knowledge sharing processes that the teams went through during the projects. This would have made it difficult for the study to establish causation (Venkatesh and Vitalari, 1991). The use of a longitudinal case study approach helped to overcome this problem, as it allowed for operational links to be traced over a period of time (Yin, 2003), to help establish causation.

The aim of the research was to gain insight into the knowledge sharing practices of project teams. Therefore, project teams were the "unit of analysis" that Yin (2003, pp. 22) states should be identified as part of the research design, in order to define what each "case" in the research represents. In terms of the number of cases, two project teams were studied. Whilst a single case could be used to study the sharing of knowledge *within* teams, two project teams were the minimum number of cases that could be used to study the sharing of knowledge *between* teams. The reason that the minimum number of cases possible were focused upon was that it would allow the most in-depth study possible of the phenomenon, whereas increasing the number of cases may have led to diluting the level of depth in which the phenomenon could be studied. The use of a small number of cases does, however, have implications for the generalisability of the findings from the research. Lee (1989) remarks that single case studies feature unique and non-replicable events, leaving such studies open to criticism that findings may not be applicable to other settings. This limitation is particularly pertinent to the aspect of this study investigating the sharing of knowledge *between* project teams, as there is only one example to draw upon. In the case of studying the sharing of knowledge *within* teams, there will, however, be two examples to compare and contrast, which greatly increases generalisability (Yin, 2003).

This investigation is based around two project teams working on projects to increase the level of engagement between scientists and the general public, to raise levels of public understanding, trust and interest in science. These project teams are particularly focusing on public engagement with the so-called "hard" sciences, such as physics, biology and chemistry. In order to distinguish between the two project teams in this research, they will be labelled Project Team A and Project Team B.

Project Team A are working on a research project which is investigating how culture can be changed to increase the level of engagement between scientists and the general public. The project team consists of three members: a Principal Investigator, a Co-Investigator and a Research Fellow.

Project Team B are working on a research project which aims to develop a computer system to provide advice for scientists involved in public engagement. The project aims to carry out the three elements of design, delivery and evaluation of the computer system. As with Project Team A, this project team also consists of three members: a Principal Investigator, a Co-Investigator and a Research Fellow. Please note that these three members are not the same as the three members in Project Team A.

Whilst both project teams have the primary members above, there are other stakeholders of the project teams, such as committees/steering groups and individuals whose expertise will be used for a specific element of a project. The roles of these other stakeholders are described in further detail in Chapters 4-6.

These two projects are being carried out by separate teams in separate organisations. Both project teams maintain their own identity and have their own deliverables.

However, the two project teams have also been linked together by their funding body (henceforth known as the Funder), as there is considerable overlap in the content of the two projects and it seems that both teams could learn from, and build upon, the groundwork each other is laying. For this reason, a Facilitator has been put in place to facilitate the sharing of knowledge between the two project teams. This person helps to bring the two project teams together at regular intervals in order for them to discuss the common issues of the two projects. This knowledge sharing is further enhanced by the use of Sharing Groups, which meet with the project teams to provide guidance and feedback to them during the course of their projects. These Sharing Groups are made up of members from different organisations with knowledge of, or an interest in, science public engagement.

The case study approach being taken in this research allows for a number of different data collection methods to be used, in order to carry out an in-depth investigation on the object of study (Hamel et al., 1993). As discussed above, the data collection methods used in this research were all chosen to be qualitative in nature. The data collection methods used in this research are detailed in Table 10:

Data Collection Methods used in this Research

Data Collection Method	Details
Semi-Structured Interviews	10 x semi-structured interviews with project team members and the Facilitator. First round of interviews held at the start of the projects and second round of interviews held eight-ten months later. Each interview is about 30 minutes to 1 hour in duration.
Observation	1 x meeting between the two project teams at the start of the projects. 1 x meeting between the two project teams and the sharing group at the start of the projects. 2 x meetings between members of one of the project teams.
Documentation	Various documentation including reports, agendas of meetings and budgets.

Table 10

Interviews were used as they allowed the researcher to investigate knowledge sharing from the perspective of the participants (King, 2004). These perspectives were important as the participants had a much greater involvement with the projects than the researcher did, which meant that they knew and understood what occurred in the projects in the greatest detail. Interviews also allowed the researcher to probe participant answers to gain a higher level of detail and obtain clarification (Miller and Brewer, 2003). Interviews also needed to be used for this research, as much of the knowledge shared in the projects was likely to be tacit in nature, as discussed in Chapter 1. As this type of knowledge exists in an individual's mind, it would not have been possible to study it without talking to the individuals who held it.

Interviews were conducted at the start of the projects and then follow up interviews were conducted 8-10 months later. The interview schedule is presented in Table 11:

Interview Schedule for Data Collection in this Research

Date of Interview	Interviewee
November 2006	Project Team A Research Fellow
November 2006	Project Team A Principal Investigator
November 2006	Project Team A Co-Investigator
December 2006	Facilitator
December 2006	Project Team B Co-Investigator
December 2006	Project Team B Principal Investigator
August 2007	Project Team B Co-Investigator
August 2007	Project Team B Principal Investigator
September 2007	Project Team A New Co-Investigator
September 2007	Project Team A Principal Investigator

Table 11

The Research Fellow in Project Team B chose not to participate in the interviews and, as a result, none were conducted with him. A follow-up interview could not be conducted with the Facilitator due to him being taken ill. As discussed in Chapter 4, Project Team A restructured themselves, removing the Research Fellow role in the project team and replacing the Co-Investigator with a new one. This led to follow up interviews only being held with the Principal Investigator and New Co-Investigator in Project Team A.

Interviews were conducted on a one-to-one basis between the researcher and each participant. The one-to-one nature of the interviews was chosen in order to allow the researcher to explore issues with each participant in the greatest depth possible. Group interviews would not have allowed the same depth to be achieved, as well as also having the disadvantage of not being confidential (Patton, 2002). This confidentiality issue was particularly pertinent to this research, as one of the aspects of the research was to potentially identify barriers to knowledge sharing in project teams. If such barriers were caused by other members of the team, these issues may not have been discussed in a group interview, as participants may not want to openly criticise or offend their colleagues. However, in one-to-one interviews, the participants could be guaranteed confidentiality by the researcher, which allowed participants to be more open with their views on any barriers encountered.

Interviews were semi-structured in nature, as this approach allowed data to be collected with a degree of flexibility to allow interviewees to digress and raise other interesting points, potentially relevant to the research (Miller and Brewer, 2003). It is argued that this was the best approach, as having a fully-structured interview could have restricted new points being raised by interviewees, whilst fully-unstructured interviews could have led to interviews not covering the research topic. Questions asked during these semi-structured interviews were open-ended, in order to give interviewees as much of an opportunity as possible to provide answers rich with information.

All interviews were conducted at the place of work of each participant, which gave the researcher the opportunity to see participants in their natural setting – a key aspect of case study research (Benbasat et al., 1987). All interviews were audibly recorded using a digital voice recorder. This technique of capturing data was used, as it allowed a complete account to be obtained, which could then be reviewed and analysed in its totality several times after the interview had taken place (Gillham, 2000). As soon as possible after the interview had been completed, field notes were made to record the personal views and impressions of the researcher about the interview and the issues surrounding it. These helped the researcher to remember the context of the interview when it was later analysed.

Observation was another method used for data collection. It has been noted in the literature that there can sometimes be a difference between what people say they do and what they actually do. An example of this occurs when participants try to avoid looking bad by not disclosing what their real actions were in front of the interviewer (Bertrand and Mullainathan, 2001). Observation was used in this study to help negate the effects of this occurrence by allowing the researcher to study participant actions directly. Observation also helped to provide the researcher with information about the phenomenon and its context (Yin, 2003). Observation took place during meetings of the members within a project team and also meetings when members from both project teams were present. When it was practical, meetings were visually recorded using a digital video recorder or audio recordings were made. One meeting was not recorded in this way, due to permission not being granted to record it, although the participants were happy for the researcher to observe and take notes in this case. Video recording was the preferred method for recording meetings as it allowed the recording of visual data, such as the non-verbal interaction (Flick, 2006) between participants in the meetings. As with the interviews, meetings recorded either by video or audio allowed for repeat observation of them in their entirety (Flick, 2006). Field notes were also made of meetings as soon as possible afterwards.

Documentation was also collected, in order to corroborate and augment the data acquired from the other sources (Yin, 2003). These documents included reports, minutes of meetings and budgets. Whilst documentation can provide an excellent account of historical data, it is recognised that bias could be present within this source of data. It is therefore important to acknowledge that the documentation was almost always created for a specific audience and purpose other than specifically for the researcher and the case study, which may have led to them not being wholly literal recordings of events (Yin, 2003).

The multiple methods of data collection described above allowed for triangulation to be applied to the data collected, which is described in detail in the next section.

3.4 Data Analysis

Microanalysis was used to analyse the data, with the researcher carrying out analysis on data line-by-line, generating common categories within the data and identifying the relationships amongst them (Strauss and Corbin, 1998). Microanalysis was useful in this respect, as one of the aspects of this research was to investigate the issues involved in knowledge sharing and how these issues were, or were not, related. In order to apply microanalysis to the data collected, audio/video recordings were first transcribed. Verbatim transcription was used for the first set of interviews, which entailed transcribing them in their entirety. The use of verbatim transcription of interviews ensured that all possible significant aspects of the interview data could be analysed (Miller and Brewer, 2003), which helped to ensure that important lines of enquiry were not missed in the follow up interviews. Selective transcription was then applied to the follow up interviews, with the researcher deciding on which parts of the data were relevant for the research and transcribing them (Miller and Brewer, 2003). Selective transcription was used as only two aspects of this set of interviews were relevant for this piece of research, based upon the analysis of the data that had been collected previously. Data was selected to be transcribed only if it was relevant to one of these aspects. One of these aspects was how the project teams had progressed with overcoming the barriers to knowledge sharing that had been identified previously. The other aspect was the relationship between the faults within the project team systems that had been identified in the VSM analysis and the way that knowledge was being used/shared by the project teams (this part of the analysis is discussed in greater detail on page 62). Selective transcription was also applied in the same way to the recordings of meetings, due to the vast quantity of data that these entailed, some of which was not necessarily useful to the study of how knowledge is shared in, and between, project teams.

A three-stage process of coding is used in microanalysis (Strauss and Corbin, 1998). Electronic versions of the transcripts created for this research were coded using the NVivo 7.0 software application. NVivo 7.0 was used for this research as software applications for qualitative data analysis provide a much more efficient way to manage the data. Dey (1993, pp. 57) sums up the importance of managing data in that "*given the sheer volume and complexity of qualitative data, failure to manage the data efficiently means failure to analyse the data effectively*". The NVivo 7.0 software application was chosen as this family of software applications is well suited to data analysis in longitudinal projects with varied data types (Barry, 1998), such as this piece of research. However, a concern about NVivo 7.0 is that its Tree Nodes structuring facility could lead to researchers imposing fixed hierarchical conceptualisations on the data, which may not be the most appropriate method for analysis (Crowley et al., 2002). Whilst NVivo 7.0 was used in this research because of its data management efficiency, due to the criticism noted above, the researcher was aware to not rely solely on the software application.

Coding involves taking small fragments of text from the data, which can lead to contextual information from the data being lost (Bryman, 2001). For this reason, coding was conducted solely by the researcher for this research, as other analysts would not have had the same level of understanding about the context surrounding the data, leading them to potentially misinterpret it. The coding for this research was carried out in the three stages described by Strauss and Corbin (1998), as these stages offer a comprehensive approach to coding data. It should, however, be noted that these stages were not carried out linearly, as the analysis required the stages to occur simultaneously and repeatedly (Hoepfl, 1997). The first stage was open coding, which involved the researcher going through each transcript line-by-line and identifying concepts and properties within the data (Strauss and Corbin, 1998). These concepts and properties were then segmented into common categories within the NVivo 7.0 software application. The second stage was axial coding, where the categories identified in the first stage were related to higher-level categories (Strauss and Corbin, 1998). These higher-level categories tend to group several of the categories found in open coding together and so relationships between the categories in the data began to emerge. Categories found in the previous stage were moved around in the Tree Nodes facility of the NVivo 7.0 software application, until they were grouped together under logically named higher-level categories created by the researcher. The final stage was selective coding, where all levels of the categories were integrated and refined (Strauss and Corbin, 1998). At this stage, the researcher kept refining all of the categories and removed any duplication until clear relationships between them were identified, leading to the development of a theory about the data.

Whilst coding remains the standard method for analysing textual data, it is not without its limitations, especially in terms of validity. The validity of coding is open to considerable doubt, given that there are no methodical procedures for assessing the validity of the analysis (Eysenck, 2004). Thomas (2006) emphasises this point by stating that different researchers may produce findings which are not identical, with categories that do not overlap, when analysing the same set of data. Due to there being no methodical procedures to assess validity, it cannot be ascertained which researcher has produced the more valid interpretation of the data when this happens (Eysenck, 2004). For this reason, it is recognised for this research that the interpretations in the coding that lead to the findings will be, to a certain extent, shaped by the assumptions and experiences of the researcher (Thomas, 2006).

The multiple methods of data collection described in Section 3.3 allowed for triangulation to be applied to the data collected. Triangulation enhances confidence in the findings and conclusions of research by developing "*converging lines of enquiry*" through finding corroboration amongst different sources (Yin, 2003, pp. 98). Two of the types of triangulation defined by Denzin (1970) were applied in this research. One type was methodological triangulation, which was used to find corroboration amongst the different research methods of interviewing, observation and documentation. In order to do this, the researcher looked for corroboration between what was said in the interviews and what actually happened in the meetings observed. Corroboration was also looked for between what was stated in the documentation and what was said in the interviews and observed in the meetings. The other type of triangulation used in this study was data triangulation, which was used to triangulate the different sources of data collected using each research method. In order to do this, the researcher looked for corroboration between what each participant said in their interviews compared to both what they had said in their other interviews and to what other participants had said, corroboration between what occurred in each observed meeting and corroboration between what each document collected stated. In cases where conflicting findings were made from the data, the researcher collected more evidence to identify the reasons for the conflict and presents these differences in the findings made in Chapters 4-6.

During the data analysis, the project teams were analysed in the context of the VSM. As stated in Section 3.2, this approach is based upon the inquirer's apprehension of the situation and is therefore unique to each inquirer. Therefore, investigator triangulation, where data is collected and interpreted by more than one researcher and then triangulated (Bryman, 2004), could not be undertaken in this study as the uniqueness of the analysis meant that it could not be replicated by a different researcher.

In order to carry out the VSM analysis, the stages of the Viable System Diagnosis process by Flood and Jackson (1991) were carried out. This process first entailed identifying each system, establishing its purpose and determining its wider context. The process then describes a number of steps to analyse each system in terms of S1 to S5 of the VSM. Through this analysis, cybernetic strengths and weaknesses of each system were identified, which enabled the researcher to diagnose any faults present within them. Once the faults had been identified, the researcher used Table 7 developed in Section 2.5 to assist in identifying any deficiencies in knowledge usage/sharing that could have led to these faults within each system. In order to do this, the researcher first identified the knowledge types that Table 7 stated needed to be used/shared in the parts of each system where the faults had been found. Then, by basing some of the questions asked in the second round of interviews around this, the researcher determined whether the types of knowledge identified as being needed were actually present within each system. This enabled the researcher to analyse the relationship between the faults within the systems and the way that knowledge was being used/shared by them.

3.5 Justification of Using the VSM for Analysis

The reasons for using a systems thinking approach have already been discussed in Chapter 1 and it was identified that it would allow the researcher to analyse a complex situation through a structured approach. It was also identified in Chapter 1 that many different systems thinking approaches exist, which were shown to have particular traits in Section 2.2. This section builds on this and argues why the VSM was the most appropriate modelling technique to use for the analysis conducted in this research.

As identified in Section 2.2, systems thinking approaches are classified on the basis of being hard or soft. Systems thinking approaches that are purely hard approaches, such as operational research methods, were shown to be applicable to situations that are well structured and have desirable outcomes which can be defined (Checkland, 1983). Whilst project teams have a desirable outcome that can be defined (i.e. completing the assigned task of the project), it is argued here that project teams are only partially well structured. Project teams consist of humans, each with their own interpretation of a situation and driven by their own motives. Projects are also characterised by regular changes, which occur over time, as identified by Turner (1999). For this reason, purely hard approaches would be unable to cope with the only partially structured nature of the situation being analysed.

This, therefore, suggested that a more soft systems thinking approach was necessary because, as identified in Section 2.2, a soft approach is able to deal with less structured situations involving human beings (Checkland and Scholes, 1999), as are present in project teams. However, the purely soft systems thinking approaches, such as soft systems methodology, are highly interpretive in nature, which focus on changing social systems through changing people's world views (Flood and Jackson, 1991). This approach means that it ignores the possibility of changing systems by modifying their structures. Whilst it was identified that project teams are only partially structured, the researcher felt that, by neglecting the structure of them completely, it might have led to useful insights being missed. Flood and Jackson (1991) also highlight that soft systems methodology neglects different subcultures that can be present within social settings. Function-specific subcultures were identified in Section 2.7 as regularly being present in organisations (Schein, 1996), which in turn become present in cross-functional project teams, where members are drawn from these different functional subcultures. These subcultures, each with their own political agendas and processes, may prevent project team members from changing their world view to a common one, as soft systems methodology requires. In this instance, soft systems methodology cannot be applied properly (Jackson, 2000).

Given the limitations of the purely hard and purely soft systems thinking approaches shown above, it became clear that a systems thinking approach that could handle *both* the structural and the social aspects of analysing project teams was necessary. As identified in Section 2.2, viable system modelling is applicable to instances that have desirable outcomes which can be defined, as in hard systems thinking, and is also able to deal with the complexity of human subjectivity in problems, as in soft systems thinking. Whilst other systems thinking approaches also sit between the extremes of hard and soft systems thinking, such as the "soft" version of operational research, the VSM also has other features particularly relevant to this investigation. One of these features is that the VSM models how the system of interest interacts with its external environment. This is an important feature for analysing knowledge sharing of project teams because they tend to use knowledge from outside their own members, as discussed in Chapter 1. The other feature of the VSM that makes it applicable for analysing project teams is that it does not view systems in terms of hierarchical relationships within them (Espejo et al., 1999). Due to members in cross-functional project teams being drawn from different functions within an organisation, traditional authority relations tend be more ambiguous between project team members (Hill, 1977), as each member may have conflicting loyalties (Ammeter and Dukerich, 2002) between the project and their own functional unit. This is important as, unlike in a functional hierarchy such as in an organisation hierarchy, each project is different, causing each one to require a different operational control approach (Turner and Keegan, 1999). This leads to the management of projects breaking "*the link between governance and operational control which prevails in the functional hierarchy... that also breaks the use of the functional hierarchy for communication and coordination*" (Turner and Keegan, 1999, pp. 300). This breakdown of structural hierarchy in projects makes this feature of the VSM particularly appropriate for analysing project teams.

For the reasons presented in this section, the VSM was selected as the most appropriate modelling technique to use for the analysis conducted in this research. The next three chapters describe the findings from this analysis.

3.6 Summary

In summary, a case study approach was taken for studying two project teams. A range of different types of qualitative data were collected from these two case studies over a 10 month period. Microanalysis was then used to analyse this data before studying the project teams in terms of the VSM, which was determined to be the most appropriate modelling technique for the analysis in this research.

Chapter 4

Project Team A and the VSM

4.1 Introduction

This chapter presents the findings from analysing Project Team A using the VSM. In order to present the analysis more clearly to the reader, the VSM diagrams in this chapter have been simplified from the VSM presented in Figure 4. Please note, however, that the actual analysis was carried out using the full VSM model in Figure 4, and the author includes more detailed information from this model where necessary.

4.2 Description using VSM

As stated in Chapter 3, Project Team A consisted of three primary members: a Research Fellow, a Co-Investigator and a Principal Investigator. The Research Fellow classified their role as "*doing the hands on research*", which entailed answering three research questions about the level of engagement between scientists and the general public. In order to answer these questions, there were a number of primary activities identified in S1 of the VSM:

- completing a literature review
- carrying out interviews
- analysing interviews
- writing reports
- carrying out action research
- writing academic conference/journal papers

In terms of S2, the Research Fellow was mainly left to co-ordinate the activities, although the Co-Investigator was on hand to offer "*supervision*". However, the main responsibility of the Co-Investigator was the day-to-day management control system of S3 and its special function S3*. The Co-Investigator stated that they were taking a "*moderator/evaluator role*" that would decide "*this is how we are going to do it on the ground*". The Co-Investigator also carried out the "*practical things like sorting out budgets and things...* [and] *facilitating, convening whatever meetings are needed*".

The Co-Investigator also played a role in the future direction of the project, and was observed by the researcher in one meeting to be actively looking for developments in their research topic area on the Internet. However, the Sharing Group discussed in Chapter 3 was the main vehicle from the external environment used to inform S4 of the VSM. The Co-Investigator and Principal Investigator were also observed in a meeting to discuss issues about the project with colleagues from outside the project team, who were also working in the research topic area, which further strengthened S4.

Despite playing a role in S4, the Principal Investigator defined their primary role as being S5 in the VSM by "*shaping the vision... to shape it, to drive it, to kind of define the boundaries*". The VSM of Project Team A is shown in Figure 6:

Project Team A Initial VSM

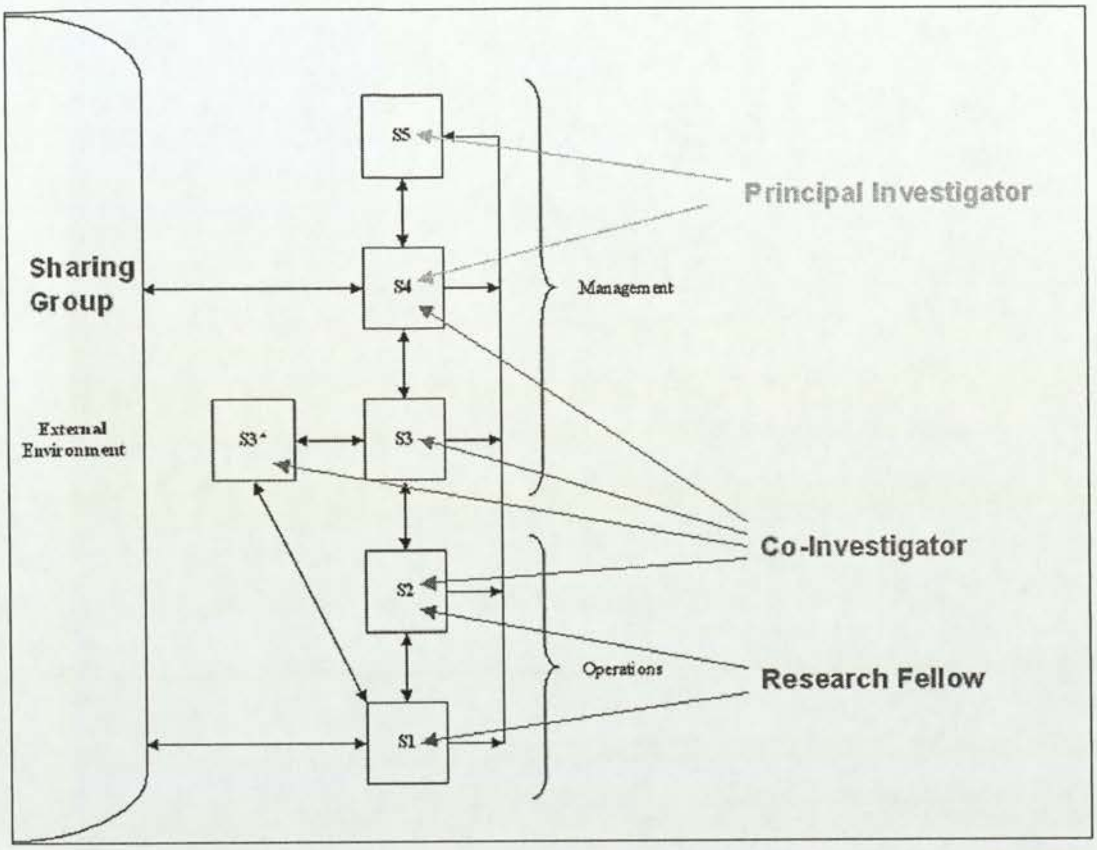

Figure 6

4.3 Knowledge Required/Shared in the VSM

When analysing the strengths and weaknesses of the different systems of the VSM for Project Team A, S3 stood out as the weakest. One of the main problems was that, whilst the broad aims and objectives had been set out by S5, there was no delivery plan developed by S3 which detailed key dates and specific milestones for the project. This lack of performance goals for each primary activity (identified in Table 7 as *C6), left the Research Assistant feeling that the project team were being "*reactive as opposed to proactive*", by just carrying out tasks when an event caused them to be done, rather than following a particular plan. The Co-Investigator said that he was so worried about this approach that he would "*occasionally wake up over this*".

Whilst the creation of a delivery plan was seen as "*absolutely crucial*" to the Research Assistant to give the project team guidance, it was also seen as important for enabling them to work out resource allocation (*A9 in Table 7). Due to the current "*reactive*" approach the project team were taking, a worry for the Principal Investigator was that "*will the people that we want to do* [the various activities in the project] *be available?... my guess is at the moment we'll be saying, oh right we're ready now, we need somebody now*" and that no-one would be available. The Research Assistant was also worried about this and said "*I think we have to be really clear who is going to do what*".

The problem with not identifying the resource allocations beforehand was further exacerbated by the strength of S4 in the project team. As noted above in Section 4.2, both the Principal Investigator and Co-Investigator took an active role in looking for developments in the external environment to suggest changes to the current project. The Sharing Group also made many suggestions to S4, further strengthening it. However, because S3 did not know what resources were being used to carry out the current tasks, it was unable to look at innovation proposals from S4 (*C12 in Table 7) and determine whether there were enough resources available to implement them (*C11 in Table 7). This led to incomplete innovation proposal reviews to be completed by S3 (*F2 in Table 7).

These incomplete innovation proposal reviews caused a problem at S5 in the VSM. The Principal Investigator who carried out the role of S5 was an exceptionally visionary person who said they "*would like to change the planet so, you know, why not aim for that?*". Due to this, she had a tendency for adding some of the innovation proposals from S4 to the project goals (*F6 in Table 7) without proper consideration of whether the project team had enough resources to do so. An example of this occurred in one of the meetings the researcher observed, when the Sharing Group suggested an extra research question could be added to their research project. S5 chose to add this extra research question and so it became an extra primary activity in S1 (via *F6 in Table 7, then *C14 in Table 7 and *A10 in Table 7). Once this addition was made to S1, it left the Research Assistant responsible for the primary activities feeling "*really, really uneasy because I don't think what we're coming up with is achievable in 2 years*" and that "*there was so much kind of vision and aspiration going on that it was too big – what we were trying to go for and what we were saying that we could achieve*". This led to further calls from the Research Assistant for S3 to create a delivery plan, which could be used to identify what needed to be done so they could "*set priorities*". The Research Assistant said that this could then be used to "*narrow down a bit*" the number of primary activities in S1, as the priorities set would identify the tasks that were crucial to the project, as well as those that were less important and so could be removed.

Due to S3 not defining what needed to be done and by when, it could also not formally set how it was going to check whether tasks had been achieved satisfactorily (*C6 and *C7 in Table 7). The Research Assistant highlighted that "[the Principal Investigator's] *success indicators or* [the Co-Investigator's] *might not be the same as mine and we've never really had the chance and time to kind of sit down and look at such things*". This added to the Research Assistant's "*worries*" as she was concerned about how they would check that the project was "*going to be a quality achievement?... there's a lot of credibility going on and if we don't get the process right or what have you, you know, then credibility becomes an issue. So I think we have to be really, really careful about those things 'cos right now there's an awful lot of credibility around science and community engagement... we don't want to upset that credibility*".

In order to correct the weak S3 issue, the project team decided to change its structure, as shown in Figure 7:

Project Team A Restructured VSM

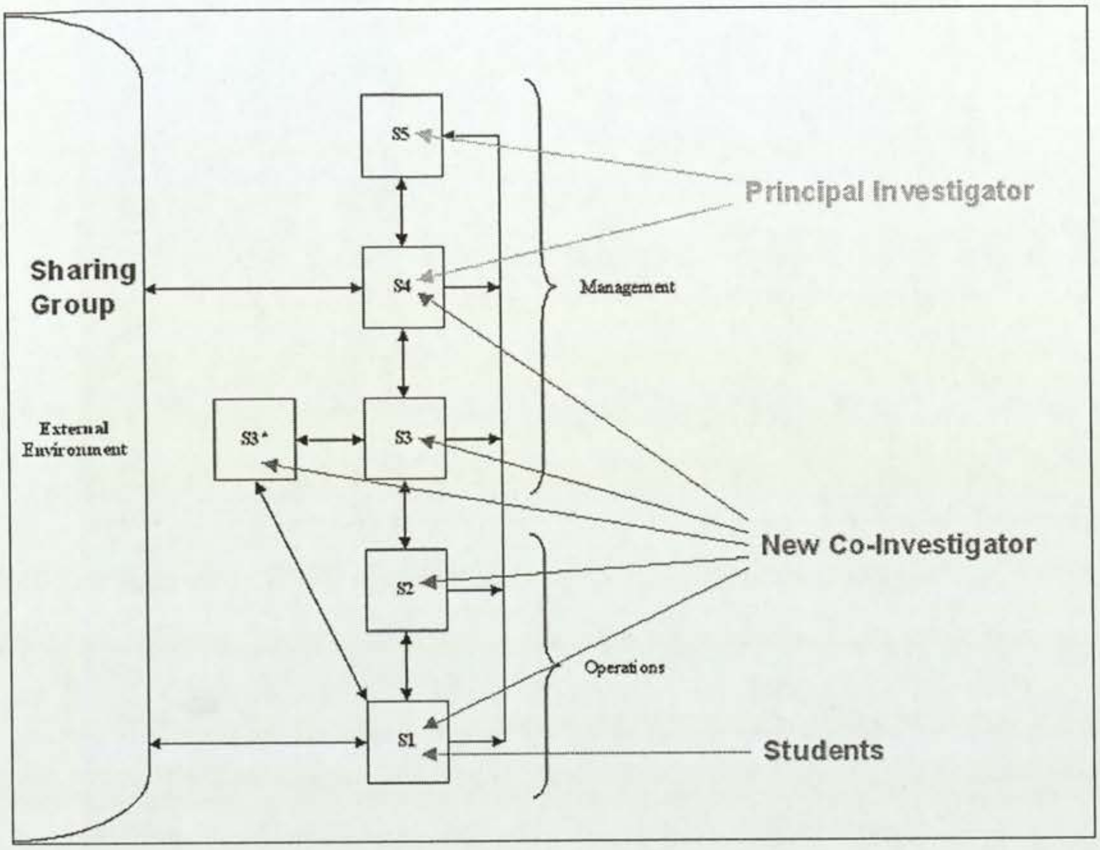

Figure 7

The project team decided to use "*students who could do chunks*" of the S1 activities, which the Co-Investigator said would force them to require a "*very clear project plan now with specific tasks*" so that students with limited knowledge of the project would have enough guidance to carry out the tasks. This use of students to carry out tasks also led the project team to no longer need a full-time Research Assistant. Any tasks that the students could not do, due to lack of experience or time, became part of the Co-Investigator's role. The original Co-Investigator also left the organisation and was replaced by a new one, henceforth called New Co-Investigator.

The students used to carry out the S1 activities were postgraduate students who were being funded to develop their research skills and "*then try to apply that in a practical* *situation under supervision*". This supervision was undertaken by the New Co-Investigator in what now had become a much stronger S3. S3 now provided "*checklists*" to the students to ensure that they had clear performance goals (*C6 in Table 7). The students were asked to write up aspects of their work at various points, and the New Co-Investigator said when students have "*written bits up... I've checked that and we've moved along in that sort of way*", so that actual performance and performance goal misalignment (*C7 in Table 7) could be identified. This enabled the:

- completing of a literature review
- carrying out the interviews
- analysing interviews
- writing reports

primary activities identified in S1 in Section 4.2 to be carried out.

The Principal Investigator also noted that S3 regularly checks now "*how things are going relative to the milestones*" since a delivery plan had now been created, so that actual performance and performance goal misalignment (*C7 in Table 7) could be identified. Nevertheless, due to the earlier problems with S3 identified above and the change in the structure of the project team, the New Co-Investigator stated "*the thing that has slipped has been time... I think* [the project] *is now 6 months or 9 months longer than* [the] *original timetable*". The Principal Investigator further highlighted the project falling behind schedule by stating that "*we are behind, we negotiated a 6 month increase in timeframe with* [the Funder]".

Through creating a delivery plan which allowed the project to become "*focused...* [with] *clear phases and stages*", it enabled S3 to determine the resource allocation (*A9 in Table 7) for the primary activities in S1. Once these had been established, S3 was able to look at innovation proposals from S4 (*C12 in Table 7) and determine whether there were enough resources available to implement them (*C11 in Table 7). This led to S3 being able to carry out much more complete innovation proposal reviews

(*F2 in Table 7) than it had before, as it was able to determine if innovation suggestions were feasible. This let S5 change project goals (*F6 in Table 7), but this time knowing that the resources were available to do so. Given the extra confidence this gave the project team, the project became "*slightly more ambitious in scope*", but they were now confident that they could complete it as they knew they had the resources to do so.

Despite appearing to have a strong S4, the Principal Investigator felt that the project team were not as strong in this area as Project Team B were, who used an additional Steering Group. She believed that this would result in fewer relevant developments in the external environment (*E2 in Table 7) being identified that could be used for reflection. This led her to suggest that not having a Steering Group was "*a flaw*" of Project Team A.

4.4 Enablers/Barriers to Knowledge Sharing in the VSM

An issue that Project Team A faced was a lack of time to actually share knowledge amongst the members. The Principal Investigator was often working abroad and the Research Assistant highlighted that this sometimes restricted the speed with which knowledge sharing within the group could take place because "*a lot of times it's just trying to get hold of* [the Principal Investigator] *and get the answers out of her because she's just all over the place*". The Co-Investigator was also a busy person, about whom the Research Assistant said "*I barely see [him]. I mean, weeks will go by and I won't see him or have any contact with him 'cos he's off doing whatever he's doing, his kind of projects and stuff, and I'm off doing whatever I'm doing in my projects and stuff*". This caused concern for the Research Assistant who said it "*worries me a bit, we're all kind of going off in other directions and then coming together and you know, kind of planning together, and then going off again*". This issue appeared to stem from the fact that, unlike Project Team B, the project team rarely saw each other to share knowledge through informal methods and they did not establish regular meetings for knowledge sharing either. The New Co-Investigator stated that the project team had meetings at times when they felt that it was "*appropriate*". However, these could be highly infrequent, with the Primary Investigator noting that the frequency of project team meetings "*varies a lot*", with them at one stage having a "*two month gap and then a three month gap*" where the project team members did not have any meetings to share knowledge in at all. This was partly overcome by the use of e-mail, which was defined as "*key*" to enable knowledge sharing within the project team and was used as an alternative to face-to-face meetings. The Principal Investigator gave several examples of documents that had "*gone backwards and forwards and* [development of them been] *iterated*" over e-mail. Nevertheless, the heavy reliance on electronic communication appeared to restrict the amount of knowledge that was shared. For example, during the second interview with the Principal Investigator, she admitted that she did not really know what had been going on in the project lately, as she had not had a meeting with the project team for three weeks. Whilst it was perhaps not important for the Principal Investigator to get too bogged down with the exact progress of each primary activity in S1, she felt it would "*have been really nice*" if she had been brought up to speed on whether knowledge had been shared between the New Co-Investigator and Project Team B, to assist her in the future direction planning activities of S4. This had not been conveyed in any of the e-mail communications, although she intended to have a meeting with the New Co-Investigator to enquire about it "*within the next ten days*" after the second interview had been carried out.

The Co-Investigator also highlighted a barrier to knowledge sharing within the project team was that the project team members were drawn from different functional areas of the organisation. He said that "*there's an interesting tension between the grounded scientists and the theorising, problematising social scientists and that's in the nature of all this really*". Despite this, there was no real evidence to suggest that this had created too much of a barrier for the project team.

4.5 Summary

This chapter has identified how important S3 is for a project team to be viable. It has shown specifically that performance goals for each primary activity (*C6 in Table 7) must be identified as this has a direct impact on the ability of S3 to work out resource allocation (*A9 in Table 7). This needs to be done so that S3 can look at innovation proposals from S4 (*C12 in Table 7) and determine whether there are enough resources available to implement them (*C11 in Table 7). This in turn gives S5 complete information in innovation proposal reviews (*F2 in Table 7) to decide on whether the innovations proposed should be implemented and project goals be adapted (*F6 in Table 7), ensuring that S1 has the resources to complete the required primary activities. Performance goals also needed to be identified so that it was possible to check whether tasks had been completed satisfactorily (*C7 in Table 7).

This chapter has also suggested that the use of external reflection in terms of the Sharing Group was important as the project team members were so busy with carrying out the tasks in the project, that it helped them to take a step back and identify future directions that possibly would have not been identified otherwise.

This chapter also identified that time needed to be made to carry out knowledge sharing activities, to enable it to occur. It appears that face-to-face meetings allow a greater amount of knowledge sharing to occur than electronic communication does. Finally, it was also identified that attention needed to be paid to the different perspectives and cultures of the project team members, arising from them being drawn from different functional areas of the organisation.

Chapter 5

Project Team B and the VSM

5.1 Introduction

This chapter presents the findings from analysing Project Team B using the VSM. As in Chapter 4, in order to present the analysis more clearly to the reader, the VSM diagram in this chapter has been simplified from the VSM presented in Figure 4. Please note, however, that again the actual analysis was carried out using the full VSM model in Figure 4, and the author includes more detailed information from this model where necessary.

5.2 Description using VSM

Project Team B mirrored Project Team A in many ways. It too consisted of three primary members: a Research Fellow, a Co-Investigator and a Principal Investigator. The Principal Investigator defined the role of the Research Fellow as being "*the person who's actually going to be doing the research. I mean, again he's a social scientist. He's going to be going out and using focus groups, he's going to be writing questionnaires, and all of those things*". In terms of this research, the aim of the project was to "*design, develop and evaluate*" a computer system, which would be used to help to increase the level of engagement between scientists and the general public. In order to do this, there were a number of primary activities identified in S1 of the VSM:

- completing a literature review
- carrying out questionnaires
- carrying out focus groups
- analysing data
- designing the computer system based on the results

- writing reports
- developing the computer system
- testing the computer system
- evaluating the computer system
- writing academic conference/journal papers

However, in contrast to Project Team A, the Primary Investigator stated the Co-Investigator of Project Team B would also carry out a "*primary researcher*" role in the project, with the Co-Investigator suggesting that he would carry out "*the guts*" of the work along with the Research Assistant. In order to carry out some of the primary activities in S1, Project Team B also needed to acquire assistance from the external environment, as they were deficient in both time and knowledge to carry out some of these tasks. The Co-Investigator highlighted this by stating that there were "*also other people that we'll bring in* [at] *various aspects at the production phase*".

In terms of S2, the Research Fellow and Co-Investigator co-ordinated the primary activities, with the Co-Investigator explicitly acknowledging that he would play a "*co-ordinating*" role. The Co-Investigator also stated that he was responsible for the "*day-to-day management*" control system of S3 and its special function S3*. The Principal Investigator also took part in S3 and S3* by defining his role as "*oiling the wheels*" to ensure that the project was moving in the right direction, by providing a "*check and a balance*". The Principal Investigator also played the role of resource allocation in S3 and stated that it was his job to "*make sure* [the primary activities] *get the resources*" they needed.

The Principal Investigator also played a role in S4 by "*talking to funding bodies, identifying where we can kind of work with them*". The Co-Investigator also played a role in S4 by looking for future directions that were "*emerging as we go along*" during the project. However, the Steering Group, discussed in the Section 5.3, and Sharing Group, discussed in Chapter 3, were the main vehicles from the external environment to inform the S4 element of the VSM.

The Co-Investigator also carried out the S5 element of the VSM, with the Principal Investigator saying that "*I see this pretty much as* [the Co-Investigator's] *project*" and so was responsible for setting the overall direction of the project. The VSM of Project Team B is shown in Figure 8:

Project Team B VSM

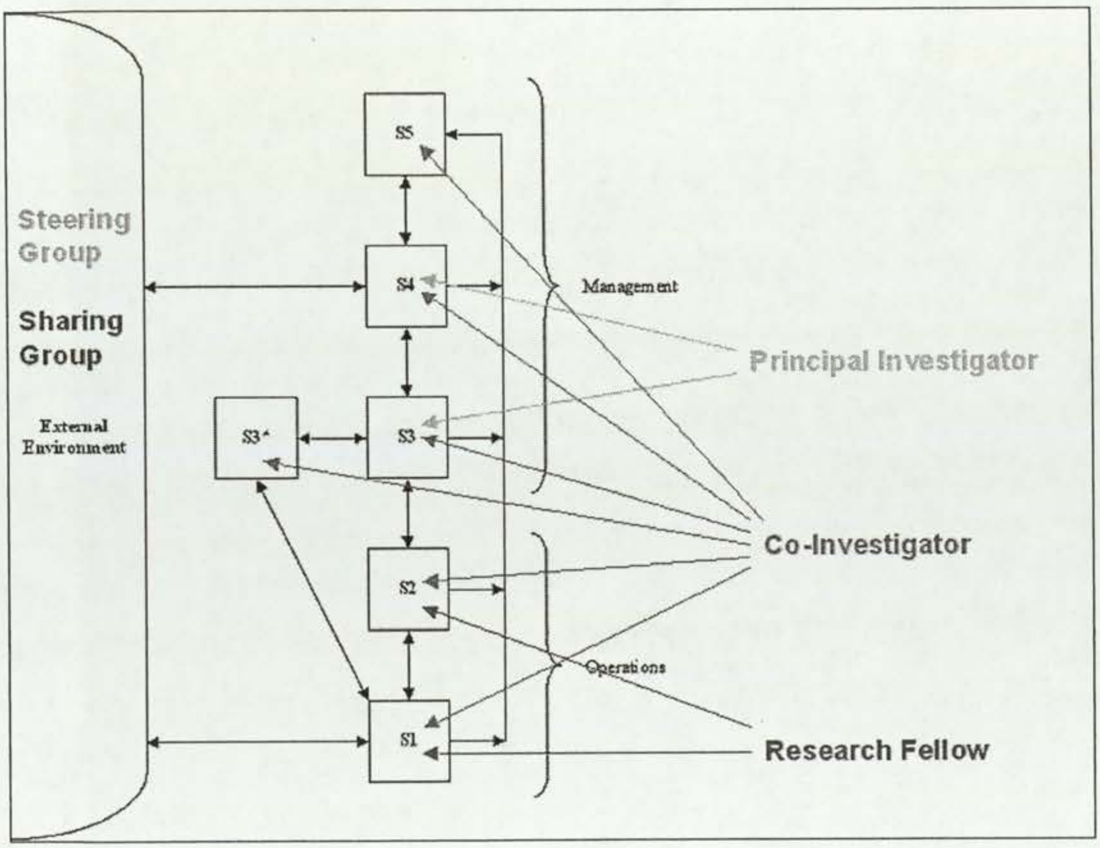

Figure 8

5.3 Knowledge Required/Shared in the VSM

In carrying out the analysis, no particular weaknesses were identified by the VSM for Project Team B. Viability appeared to have been achieved by the project team as the Co-Investigator stated that the project was "*on track*" in terms of progress, and the Principal Investigator said that the project was "*pretty much going to plan*". In contrast to Project Team A who had fallen behind in their project, however, Project Team B were found to have a very strong S3, which appears to have been the differentiating factor between the two project teams. From the very beginning of the project, Project Team B defined very clear goals for each primary activity (*C6 in Table 7) in terms of key dates and milestones for the project. The key dates and milestones were formulated into a document that was given to each of the members of the project team.

Due to S3 having defined clear goals, it was able to check actual performance and performance goal misalignment (*C7 in Table 7). The Co-Investigator stated that "*we check on progress once a week*". In terms of the key dates and milestones, the Co-Investigator stated that throughout the project "*we've got those in our heads*" and "*we meet on a weekly basis... to obviously check on progress*" to ensure that the project was on track in relation to this. The Co-Investigator felt that it was important that S3 did this for the project because "*you have to keep on track, you couldn't let it slack, because it's certainly a tight deadline... there isn't a lot of room for slippage*". S3 in this project team also showed that they had worked out measures available to counter actual performance and performance goal misalignment (*C8 in Table 7), if the project fell behind schedule. At certain stages when the project began to fall behind schedule, S3 decided that running some of the primary activities in "*parallel*" would bring the project back on schedule (*C8 in Table 7) and would inform S1 of its decision (*A8 in Table 7). A drawback of running some of the primary activities in parallel was that one activity would not be completed before another one started, so the first activity may not be able to inform the second activity as satisfactorily as it could have done, if the tasks had been carried out sequentially. This happened with the analysing data primary activity in S1 not being completed before the designing the computer system based on the results activity. This could result in the computer system design not being as good, as it had not been informed by the full analysis. Despite this, the Co-Investigator felt that staying on schedule in the project was so crucial that it was necessary to do this.

With S3 having defined clear goals, it was also able to check actual performance and performance goal misalignment (*C7 in Table 7) in terms of quality. The Principal Investigator stated that "*we made it quite clear, the outcomes and how we'd evaluate it and measure it... I think the key thing is, it's the same with any kind of research proposal, that you need to clearly state what your objectives are and how you're going to measure when you've achieved those objectives*". In one instance, S1 identified that it was "*harder to identify focus group participants than I thought it would be*" in the carrying out focus groups primary activity. S1 informed S3 of the actual number of participants being used in the focus group (*C1 in Table 7) and the reason why (*C2 in Table 7) they were struggling to meet the performance goal set by S3 (*C7 in Table 7). The reason (*C2 in Table 7) was that, whilst "*quite a few people came forward and said they would be willing to participate... when it actually came to get them in a room and doing it, it became more difficult*" because not everyone was available on the same date. Once this had been identified, S3 went to find that "*all the* [prospective participants] *were actually going to get together at a residential meeting for a couple of days*", and then informed S1 it should "*run* [the focus groups] *at the residential meeting when we've got them all there*". S3 working out this is an example of identifying a measure to counter the difference between actual performance and performance goal misalignment (*C8 in Table 7), and then an example of S3 telling S1 how to counter the actual performance and performance goal misalignment (*A8 in Table 7).

Another difference between Project Team B and Project Team A was in S4. Project Team B used a Steering Group, composed of members working in the science engagement domain who worked for the organisation the project team was based in. This Steering Group was used to help S4 identify relevant developments in the external environment (*E2 in Table 7) that could be used to reflect and make suggestions on how the project could be adapted (*C12 in Table 7). The project team had meetings with the Steering Group "*every three months roughly*" and gave the project team more resources for monitoring the external environment than Project Team A had. However, the researcher could find no real differences between the strength of S4 in both the two project teams.

Another difference between the two project teams was that Project Team B also had to draw on knowledge from outside the project team (*A1 in Table 7) to perform some of the primary activities in S1. Examples of this were given by the Principal Investigator who stated that the project team would use people from the computer department "*who will come in and help us design the* [computer system] *so they'll be involved in that*" and "*we also have a group of evaluation experts in* [another department] *so we'll have them involved in the kind of evaluation phase*". Whilst drawing upon external knowledge had so far been unproblematic for the project team, the Principal Investigator did note that using external knowledge from consultants to carry out tasks was more "*risky*", as S3 had less control over them to ensure that they met deadlines, as they were outside of the system boundary.

<u>*5.4 Enablers/Barriers to Knowledge Sharing in the VSM*</u>

As with Project Team A, Project Team B also had an issue with having enough time to share knowledge amongst their members. The Co-Investigator was worried about "*how much time we actually have to do sharing... that's one of the things I'm sensitive about because I know how busy* [the Principal Investigator] *and I are... so there's a kind of, I don't think there's necessarily an unwillingness to share, certainly, but I'm not sure how much practically we'll have time to do it*". The Principal Investigator also noted that "*one of the barriers is time*". Despite this, the project team appeared to have managed the time issue and the Principal Investigator stated that "*I wouldn't say that the project has actually slowed down at all because of our time or unavailability*". One of the ways the project team managed this issue was to create a specific time-slot for knowledge sharing to occur by having "*weekly formal meetings where we get together*" to share knowledge face-to-face between the project team members. The Co-Investigator stated that these meetings "*last for at least an hour... and then we just continue on if necessary, and that seems to work fine*". Along with having a specific time-slot, the Principal Investigator also felt that "*I need to make sure that I can make myself available at quite short notice*" if knowledge needed to be shared urgently.

The Co-Investigator went on to emphasise the importance of face-to-face communication in the project "*because its kind of such a complex project... you need to be able to talk to each other regularly to make sure* [it's] *going in the right direction*". Whilst the project team also relied on "*a lot of email traffic*" to share knowledge, the Co-Investigator said that when they needed to go through something in detail, such as in the developing the computer system primary activity of S1, "*you can't do that by email, you've got to sit face-to-face... you just couldn't do that easily any other way*".

Whilst the Principal Investigator did go abroad for a few weeks to carry out some work, this was far less than the Principal Investigator in Project Team A did. All of the offices of the project team members were also located much closer together than they were for the members of Project Team A. This enabled much more knowledge to be shared on an "*informal basis*". For example, the Principal Investigator said that "*I usually bump into* [the Research Assistant] *when he's in the department, usually it's having a conversation with him about how it's going and what are the issues...* [we] *go for a cup of coffee, or something like that, just to catch up on where we are* [in the project]". The Principal Investigator also said that he and the Co-Investigator were "*bumping into each other and talking about* [the project] *on an informal basis all the time as well*". The Co-Investigator stated that less informal knowledge sharing occurred between himself and the Research Assistant, "*it's not as if I bump into him in the corridor very often because he's in a different building*". Nevertheless, he did state that some informal knowledge sharing occurred "*occasionally*" between them, as the Research Assistant would "*come over and chat to me or I can go over and chat to him*" whenever there was a need to do so.

The Co-Investigator felt that "*in terms of the enablers, I mean knowing these people on a personal level, I think obviously is extremely useful*" for sharing knowledge within Project Team B. The Co-Investigator felt that this stemmed from building up trust with the other members in the project team, "*a lot of collaboration* [has] *gone in the past and to be fair that's why we chose the team because I know I can trust them and they all volunteered because presumably they can trust me at some level*". The Co-Investigator also highlighted that this trust had been built over time "*because I've been here for nearly 7 years now and have worked with an awful lot of people in different areas and stuff, there's a kind of level of trust which kind of builds up when working with people and you can only build it up I think by actually working with people*". The Principal Investigator also highlighted that he felt that it was important to "*develop a relationship with people, which is a relationship of trust... ensur*[ing] *that on both sides that you are communicating*". He also stated that it was a "*simple thing to do, for half an hour go with someone for coffee... it enables people to talk a little bit more about their concerns or any, kind of, worries. They may not have any, in which case, you might talk about football or the other things that are going on*". He felt that developing a relationship of trust like this allowed the other project team members to "*feel that they can tell me things and I can then give them advice*", whereas problems or issues may have been hidden from him if trust was not present between him and the other members.

As in Project Team A, the Co-Investigator of Project Team B also highlighted a barrier to knowledge sharing within the project team was that the project team members were drawn from different functional areas of the organisation. He said that "*it's because you're working across the kind of* [hard] *science-social science divide that exists... there are kind of processes of "culturation" where people learn how to do their particular area of academic expertise which actually says* [hard] *science good-social science bad, or social science good-*[hard] *science bad. I personally think that's ludicrous, but there you go, you know, it's there*". Despite this, there was no real evidence to suggest that this had created too much of a barrier for the project team.

5.5 Summary

This chapter has reinforced the high importance of S3 in order to make a project team viable. The most significant difference found between Project Team A and Project Team B was the strength of S3. Whilst Project Team A had a weak S3 and had fallen behind schedule, Project Team B had a very strong S3 and remained "*on track*". From the very beginning of the project, Project Team B defined very clear goals for each primary activity (*C6 in Table 7) in terms of key dates and milestones for the project. As identified in Project Team A, this enabled S3 to check whether tasks had been completed satisfactorily (*C7 in Table 7). S3 in the project team also worked out measures available to counter the difference between actual performance and performance goal misalignment (*C8 in Table 7) and would inform S1 of its decision (*A8 in Table 7). It was also noted that S3 had less control over knowledge taken from outside of the system, which was being used in some primary activities of S1 (*A1 in Table 7).

This chapter has also suggested that the use of external reflection in terms of the Steering Group and the Sharing Group was important, although the use of the Steering Group, which Project Team A did not use, did not appear to give Project Team B a stronger S4.

As with Project Team A, this chapter also identified that time needed to be made to carry out knowledge sharing activities, to enable it to occur. Again, it appears that face-to-face meetings allow a greater amount of knowledge sharing to occur than electronic communication does. However, a great deal of knowledge sharing was also achieved within Project Team B through informal methods too.

Trust between the members was also identified as an enabler to knowledge sharing within Project Team B.

As with Project Team A, it was also identified that attention needed to be paid to the different perspectives and cultures of the project team members, arising from them being drawn from different functional areas of the organisation.

Chapter 6

Project Teams at Recursion Level 0 in the VSM

6.1 Introduction

This chapter presents the findings from analysing the project teams at recursion level 0 of the VSM. Analysing the project teams at this recursion level allowed them to be studied in their wider context. As in Chapters 4 and 5, in order to present the analysis more clearly to the reader, the VSM diagrams in this chapter have been simplified from the VSM presented in Figure 4. Please note, however, that again the actual analysis was carried out using the full VSM model in Figure 4, and the author includes more detailed information from this model where necessary.

6.2 Description using VSM

Each project team has been analysed in terms of being embedded in two VSMs. One of these VSMs, which both project teams reside in, is the funding organisation system. The two project teams constitute the primary activities in S1 of this system. The Facilitator, as described in Chapter 3, was given the co-ordination role of S2 by "*pulling together the strands of commonality between the two project* [teams]". The Funder took on all of the other responsibilities in this VSM. The VSM of the funding organisation system is shown in Figure 9:

Funding Organisation System VSM

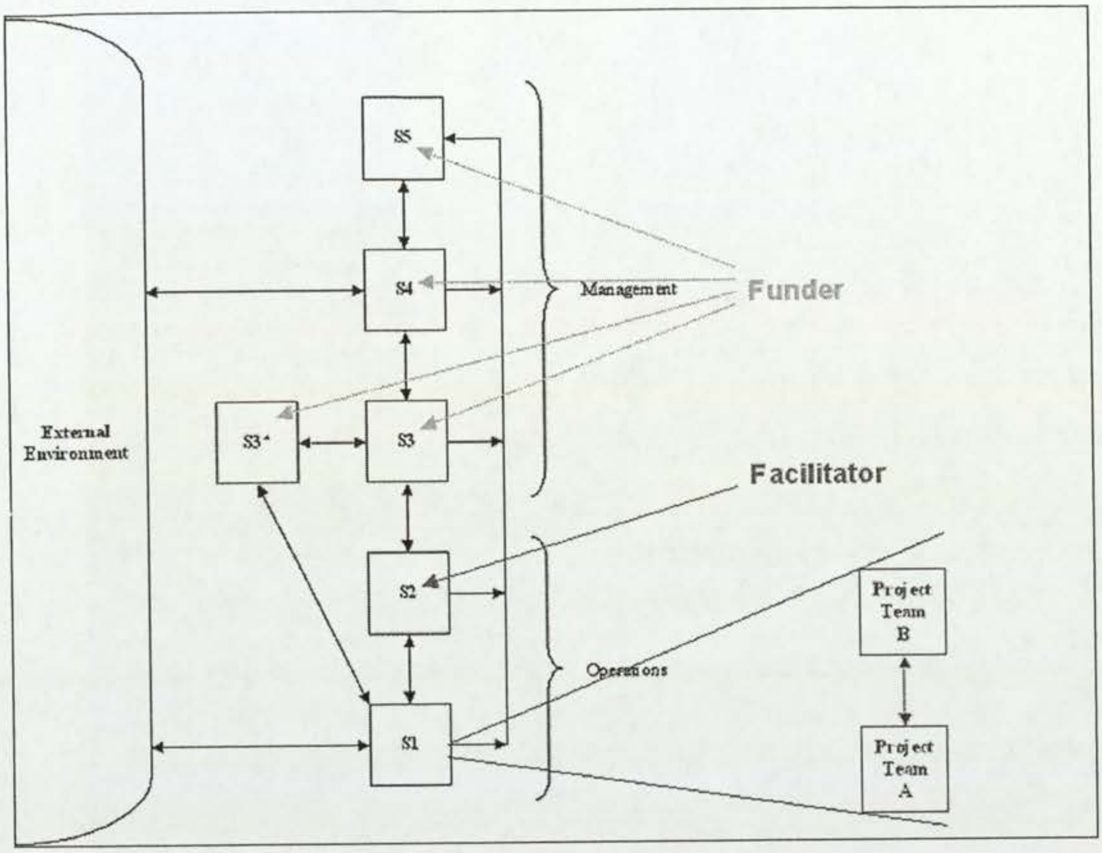

Figure 9

Project Team A was also analysed in the context of the organisation the members worked for. Project Team A constituted one of the primary activities in S1 of this VSM, but the organisation also had many other project teams working on projects related to science engagement, and these made up other primary activities in S1. A department responsible for science engagement projects took on all of the other roles in this VSM. The VSM of this organisation system is shown in Figure 10:

Project Team A Organisation System VSM

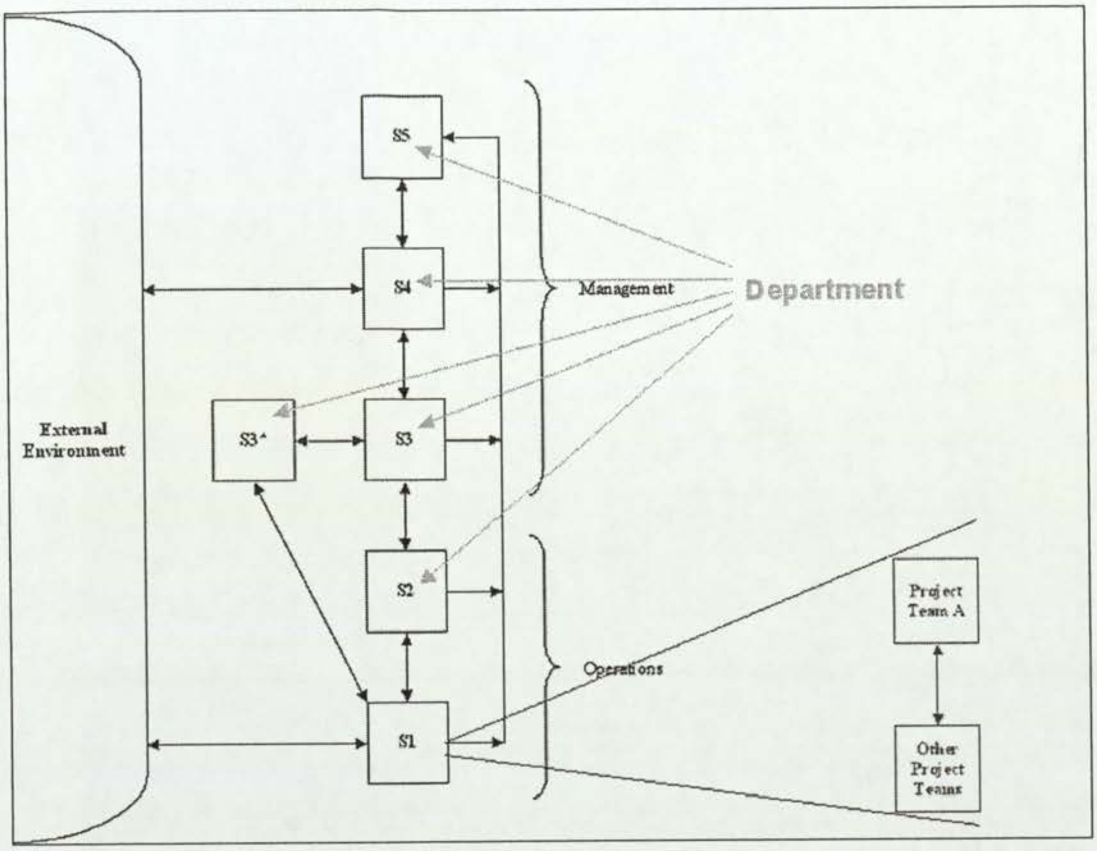

Figure 10

Project Team B was also analysed in the context of the organisation the members worked for. Project Team B constituted one of the primary activities in S1 of this VSM, but the organisation also had many other project teams working on projects related to science engagement, and these made up other primary activities in S1. However, there appeared to be no responsibility taken for any of the other roles in this VSM. The VSM of this organisation system is shown in Figure 11:

Project Team B Organisation System VSM

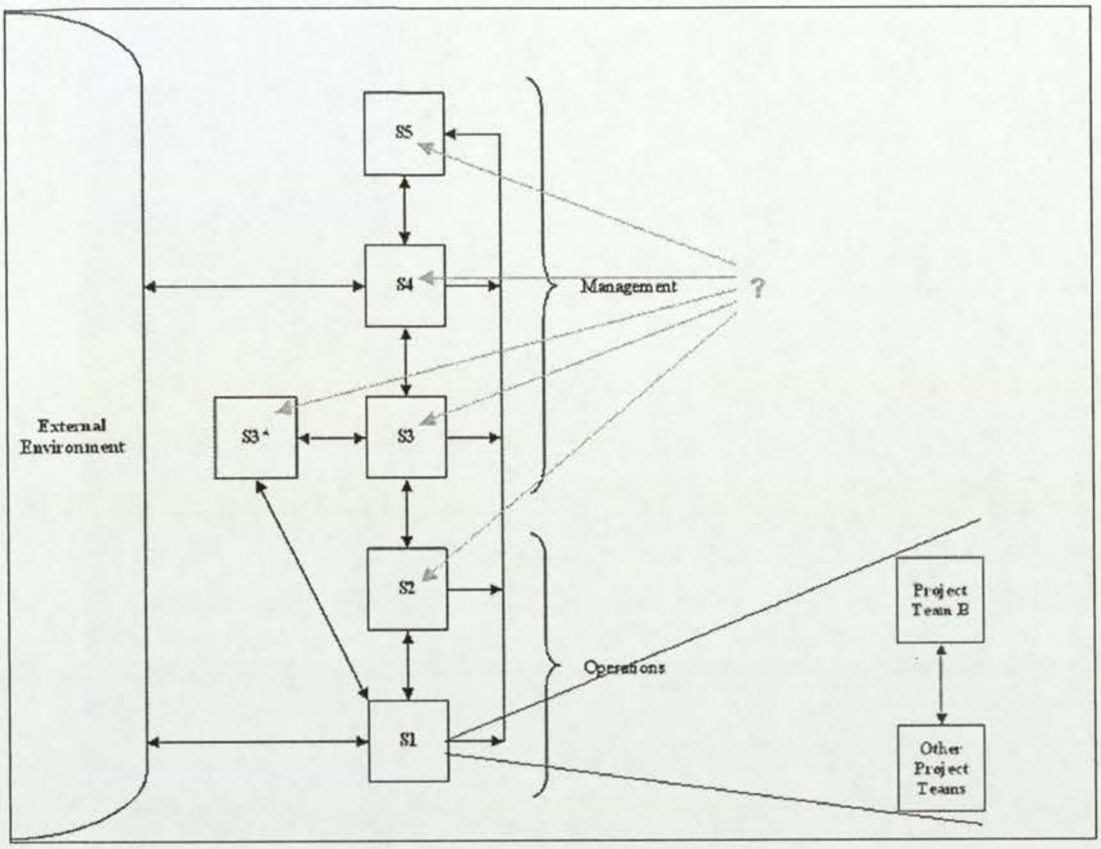

Figure 11

6.3 Knowledge Required/Shared in the VSM

When analysing the funding organisation system VSM presented in Figure 9, particular weaknesses were identified in S3, S3*, S4 and S5, i.e. the systems that the Funder took responsibility for. The Facilitator said this stemmed from the fact that the Funder is "*not awarding any money in* [the science engagement] *areas anymore... I received a letter from them saying that they weren't actually overseeing it anymore... so while* [the Funder] *was still funding* [the two projects], *it wasn't something that they were really interested in anymore*". As the Funder was no longer awarding money in this research area, it led S4 to not look for developments in the external environment (*E2 in Table 7) in the research area the two project teams were working in. Due to the Funder being no longer interested in science engagement, it also meant that the overall values, purpose and the goals in S5 (*F7 in Table 7) were no longer really centred around what the two project teams were doing. This was emphasised by the Principal Investigator of Project Team B saying that the Funder's "*objectives have changed a bit, so I'm not sure where* [these projects] *fit in with them anymore*".

In terms of S3, the Funder continued to oversee the completion of these "*legacy*" projects. However, it appears that the Funder is not really that engaged in S3 activities, reflecting perhaps its loss of interest. Project Team A said that the Funder is "*just having to oversee this* [project] *and get it done and make sure it happens*" but was not really "*interested in the intellectual content...* [which] *was more valuable*" as it would have allowed S3 to check the quality of the primary activities. Project Team B said that they "*sent* [the Funder] *a little update every so often just to give* [the Funder] *an idea of what progress is*" but they had not had "*a great deal of contact with* [the Funder]". Whilst this shows that progress updates were being given to S3, no formal performance goals for each primary activity (*C6 in Table 7) were defined by S3. Project Team A felt that, in a sense, this "*gives you a certain sense of liberty*" and Project Team B felt that it was "*quite nice to be able to just get on and do it*". However, because S3 had not set formal goals and so could not identify actual performance and performance goal misalignment (*C7 in Table 7), there was a real fear that the project teams might "*end up saying, look we've done this, and* [the Funder] *saying, well that's not what we wanted you to do*". For this reason, it was suggested that "*it would have been nicer to have had a little bit more regular formal contact with* [the Funder]".

As was observed by the researcher in two meetings between the project teams, they began to share knowledge with one another at the start of the two projects. However, during the research, the Facilitator responsible for S2 was unable to carry out his role for a period of time due to illness. Project Team B felt that because the Facilitator had been "*incapacitated for a bit... that's kind of reduced down our interactions*" between the two project teams. This left the sharing of knowledge between the two project teams unco-ordinated, as the project teams had "*not had a chance to meet up and talk*", with

Project Team B saying that "*at the moment, communication...* [between us] *is pretty poor*" and that they had "*not really exchanged ideas and information*" between themselves.

However, despite this, both project teams appeared to recognise how beneficial sharing knowledge between themselves would be, due to the similar work that they were carrying out. Project Team A said that sharing knowledge between the two project teams would have meant that they could have identified "*what have* [Project Team B] *learnt that can inform* [Project Team A] *and what have* [Project Team A] *learnt that can inform* [Project Team B]... [providing] *an opportunity here to join things up... and if we'd met in between then that's very likely to have happened, so I think it would have been beneficial*" and "*if we'd been meeting every month, the two projects would be really benefiting from each other*". Project Team B further highlighted this by saying "*within the research we have done so far, we do have findings which I think that would be useful for* [Project Team A]" and "*I think it's important that we do use* [our] *information to inform each other*".

Despite the project teams recognising how beneficial sharing knowledge between themselves would be, without the Facilitator to co-ordinate such sharing, the project teams were not proactive enough to carry out knowledge sharing between themselves of their own accord. This suggests that knowledge sharing between project teams needs to be co-ordinated. This finding was backed up when analysing the Project Team B organisation system VSM presented in Figure 11. In this VSM, S2-S5 were not really handled by anyone and this led Project Team B to say "*our* [science engagement] *is very widely spread*" with "*lots of activities that are going on within the faculty and in the departments, but at the moment we don't have any means of co-ordinating it*". They felt that "*we need to have a much more co-ordinated approach*", so that other science engagement projects can "*use the findings from* [this] *project in their own* [science engagement] *activities*". In order to do this, the project team suggested that they needed to strengthen their S2, as they felt it would be able to identify and exploit useful similarities between the several projects in science engagement that were being carried out within the organisation. They stated that "*we need to have somebody within* [the organisation] *who has a responsibility for* [science engagement]" so that "*all these things* [can] *be bought together under one umbrella with a clear strategic view and somebody who can work within the departments to make sure that we are delivering our* [science engagement] *in a fairly coherent fashion*".

The stronger S2 that Project Team B identified it needed was already present in the organisation of Project Team A. As shown in Figure 10, a department took responsibility for the S2-S5 activities within the VSM of Project Team A's organisation. Due to this co-ordination, it made it possible for "*what the* [department] *has learnt already, has helped to shape this project*". Similarly, "*looking at culture change in* [this project] *will help to inform* [other projects within the department]". One of the ways in which knowledge was shared between projects in this organisation was that "*we have a group of people who are active in* [science engagement] *right across the organisation who, come together to share good practice, and throughout the research project we've talked with them what our plans have been*". Another way that the researcher observed knowledge being shared between science engagement projects in the organisation was that, in one of the meetings observed, members from Project Team A and members from another project team came together to discuss issues from the project. Due to the strength of S2 in Project Team A's organisation, many other "*people know* [the project] *is happening*" within the organisation. However, the project team did admit that these "*people don't know yet what we're finding*", due to Project Team A having not quite completed the analysis by the time the project team members were interviewed by the researcher. Nevertheless, Project Team A planned to share their findings, once they had been made, with other science engagement projects within their organisation.

6.4 Enablers/Barriers to Knowledge Sharing in the VSM

One of the issues that both project teams identified as being a barrier to sharing knowledge between themselves was their different cultures and working practices. Project Team A noted that "*our philosophy was different*" to that of Project Team B. The Facilitator noted that "*there's big cultural differences*" between the two project teams and that they "*have different ways of working I think, which is really clear to me*". Project Team A also noted that there were differences between the two project teams in terms of language used. Project Team A said that Project Team B used some terminology when they shared knowledge that "*aren't terms I would use, so that is a potential difficulty... I think that language and definition thing will probably continue to be an issue through the whole project*".

The two project teams went through a "*get to know each other*" phase, which they felt helped to overcome this initial barrier to knowledge sharing. Project Team A said that "*understanding how the teams work and how we do things is just, you know, a critical part*" and that it took time to do so by saying that "*it gets a bit better*" each time the two project teams met. The Facilitator also supported this point by saying "*as* [the two project teams] *meet more often, I think those barriers might be broken down*". Eventually, Project Team A felt that they had learnt "*quite a bit about how the other institution works*" during this phase, although they were not entirely convinced this barrier had completely been overcome, noting that "*normally when you go into partnership with somebody you spend ages and ages and ages developing a relationship of trust and some common understanding and this is a shotgun marriage so I don't know what's going to come out of that. I've never been in an arranged marriage type of research before*". Project Team B were even more sceptical that they had truly got over this barrier by stating that they still felt they needed to "*develop those* [intra-project team] *relationships*". Reflecting about one of the first times the two project teams met, Project Team B said "*there didn't seem to be places where I could sit down and talk to individuals and find out about them, so I think that was a problem*" and "*there is a process of just getting to know people and that is a building of trust, a* *building of respect, which is actually crucial to any successful project. I think that's something which I knew we needed to do before we had the meeting and I still think we need to do*".

Due to the two project teams carrying out research projects, another barrier to knowledge sharing between them was that each project team wanted to maintain the ownership of their knowledge from the project, in order to produce academic conference papers and journal publications. Project Team A stated that a barrier was "*the whole intellectual property issue... it's clear that there's going to be some publishable outcomes from this* [research]... *and I suppose I can see that there might be tensions around that*". Project Team B also highlighted this by stating that "*one of the things that both of us are eager to understand, to make sure it works well, is the ability to share information, but at the same time have ownership of that information*". Project Team B went on to state that it was important to make "*sure that any findings we have that we can share with* [Project Team A] *and any findings they have, they share with us. But we understand that it's, you know, that that's their research and this is our research and it can inform what you do but it's not your research as it were. I think there's an interesting kind of issue around intellectual property*". Project Team B felt that the best way to overcome this barrier was to set "*clear ownership rules about it*" and ensure "*that the rules are understood on both sides*".

6.5 Summary

This chapter has identified that S3 was still important to project teams at recursion level 0. Whilst the project teams enjoyed a high sense of liberty when S3 was not present in the Funder organisation system VSM, they were also concerned that their projects might end up going off in the wrong direction. This further highlights the importance of the role that S3 plays at the project level of the organisation.

This chapter has also identified the importance of the role S2 plays in co-ordinating the sharing of knowledge between project teams. It has been shown here that, without co-ordination, the project teams would not share knowledge between themselves, even when they were aware of the existence of each other and believed that there could be a high-level of benefit achieved from doing so.

It was also found that the different cultures and working practices of the different project teams could be a barrier to sharing knowledge between them. This barrier was found to be reduced over time, when the project teams got to know one another better, but this barrier may not necessarily have been completely overcome.

Another barrier to knowledge sharing between the project teams was that each project team wanted to maintain ownership of the knowledge from their particular project. It was suggested that, to overcome this barrier, rules for defining intellectual property rights should be set.

Chapter 7

Discussion

7.1 Introduction

This research set out with the purpose of investigating the knowledge that was shared at the project level of organisations. By increasing the level of understanding of knowledge sharing at this level, this research aimed to assist organisations in getting the best out of their project teams. This research has done this by identifying a number of barriers and enablers which organisations should be aware of to increase the effectiveness of their project teams. These barriers and enablers are discussed in this chapter. This chapter also highlights the limitations of this study and possible future directions that research in this area could take.

7.2 Knowledge Sharing Within Project Teams

This research identified how important S3 is for a project team to be viable. In Project Team A, S3 was very weak and contributed to the project team falling behind schedule. If Project Team A had not addressed its S3 issue, the researcher can see no way that the project team could have moved forward with it effectively. In contrast, Project Team B was strong in each of its S1 through to S5 and remained on schedule. This supports the assertion made by Espejo and Gill (1997) and Schwaninger (2006) that a system requires S1 to S5 in order to ensure its viability is not prejudiced. Nevertheless, Project Team A remained viable, in that it still existed, during the period that it had a weak S3. This supports the belief of Jackson (1988) that social systems can still exist when not adhering to the VSM structure.

Through the analysis using the VSM, a number of relationships between the different pieces of knowledge within the project teams emerged. It was shown that performance goals for each primary activity within the project teams needed to be identified, as this knowledge had a direct impact on other knowledge within the project team. Without performance goals, Project Team A were unable to work out their resource allocation, which they needed in order to consider whether they could carry out innovation proposals. As a result, this led to the project team extending the scope of their project without proper regard as to whether they had the resources available to do so. This supports the suggestion from Achterbergh and Vriens (2002) that difficulty occurs when S3 is "weaker" than S4, as it leads the system to implement new innovations, without having the required operational capabilities to successfully carry them out.

Performance goals also needed to be identified so that it was possible to check whether tasks had been completed satisfactorily, in order to assure quality. Project Team B defined very clear and specific performance goals in terms of key dates and milestones, as well as quality, at the very beginning of their project. This enabled the project team to check whether it was on track, as well as measure the level of quality of the primary tasks being completed. Project Team B were also able to establish measures available to counter the difference between their performance goals and their actual performance, which enabled them to take corrective action quickly if they needed to.

These findings from the VSM analysis support Lynn et al. (1999) in that the identification of goals enhances performance. Both project teams had a vision, but Project Team A did not have clearly defined interim goals, which left it without a direction to follow to attain its overall vision. Project Team B, on the other hand, did specify clear interim goals but did not follow the suggestion by Lynn et al. (1999) to keep these goals stable. Project Team B had a strong S4, which enabled it to regularly identify future directions and ways of changing their project to encompass what was happening in the external environment. Some of these changes were implemented by Project Team B, necessitating the modification of (and addition to) some of their interim goals. This supports the belief of Turner (1999) that project plans change over time. This also shows that project teams adapt to their external environments, further supporting the use of the VSM as method of analysing them with its particular focus on studying such adaptive systems. However, despite Lynn et al. (1999) arguing that such goal modification is likely to increase both the cost and duration of a project dramatically, Project Team B reported no issues in this respect.

Members not having enough time to engage in knowledge sharing activities within project teams was identified as a barrier to knowledge sharing, supporting the finding made by Fong (2003). Project Team A members struggled to make time available for sharing knowledge due to other work commitments. This highlights the belief that project team members are often so occupied with completing their tasks, they may not have the time to engage in knowledge sharing activities (Purvis and McCray, 1999; Carrillo et al., 2004; Kasvi et al., 2003). This led Project Team A to concentrate just on the tasks of the project, even if they did not have sufficient knowledge to do so due to a lack of knowledge being shared between members. Project Team B followed the suggestion made by Goh (2002) and Garvin (1993) by making specific time available to share knowledge with one another, in this case at least one hour every week, leading to much more effective knowledge sharing to occur.

Due to Project Team A members being dispersed around different distant locations, and in the case of their Principal Investigator internationally, the project team were heavily reliant upon information technology to facilitate their knowledge sharing. This appeared to lead Project Team A to share less detailed knowledge between themselves. In contrast, Project Team B were much more reliant upon social interaction to share knowledge with one another. Project Team B members were located much closer together, which enabled them to have face-to-face meetings. Due to them often seeing one another around their organisation, this also allowed a great deal of informal knowledge sharing to occur between members. This social interaction allowed Project Team B to share much more detailed knowledge. These findings support the claim made by Lagerström and Andersson (2003), Pretorius and Steyn (2005) and Fong (2003) that social interaction is a much more effective method of sharing knowledge than relying upon information technology is. Project Team B did use email to support their knowledge sharing, further strengthening the finding of Lagerström and

Andersson (2003) that technology plays a subordinate role to social interaction in knowledge sharing, and is useful for sharing less detailed updates and support to project members.

Trust was also highlighted as an enabler for sharing knowledge within project teams. Project Team B felt that it enabled much more forthright knowledge sharing to occur, whereas if trust was low, important problems might have been hidden and not discussed by the project members. This supports the assertion made by Goh (2002) and von Krogh (1998) that knowledge sharing occurs less when there is low trust between members. Project Team B also highlighted, as is suggested in the literature by Fernie et al. (2003), that trust was something that was built over time, and was built upon past experiences the members had of working with one another.

It was also identified that attention needed to be paid to the different perspectives and cultures of the project team members, arising from them being drawn from different functional areas of the organisation. Supporting Schein (1996), both Project Team A and Project Team B alluded to the presence of sub-cultures within the project team, especially between the hard scientists and the social scientists. This issue did not, however, really cause either team a problem, but they were both aware of its presence.

As Huang and Newell (2003) have noted, some project teams use steering groups to monitor and control progress of their projects. This research did not find that the two project teams were using their Steering Group/Sharing Group for this purpose. The project teams were using these more as a way of reflecting back to the teams and suggesting future directions to take. The roles the Steering Group/Sharing Group played in these project teams were much more S4 roles in the VSM than S3 roles. Therefore, the Steering Group/Sharing Group were used to advise the project teams in this instance, rather than for the control purposes that Huang and Newell (2003) note they usually tend to do.

7.3 Knowledge Sharing Between Project Teams

This research identified that S3 was still important to project teams at recursion level 0. Whilst the project teams enjoyed a high sense of liberty when S3 was so weak in the Funder organisation system VSM, they were also concerned that their projects might end up going off in the wrong direction. This further highlights the importance of the role that S3 plays at the project level of the organisation, as well as the importance of goals to set a direction, as stressed by Lynn et al. (1999).

This research also identified the importance of the role that S2 plays in co-ordinating the sharing of knowledge between project teams. This role was initially taken on by the Facilitator but during this research he became unwell and was unable to perform the role. Following this occurring, this research showed that, without co-ordination, the project teams would not share knowledge between themselves, even though they were aware of the existence of each other and believed that there could be a high level of benefit achieved from doing so. This finding supports Carrillo et al. (2004), Pretorius and Steyn (2005) and Newell et al. (2006) in that someone needs to be made responsible for the knowledge sharing between projects for this to occur effectively. The Funder had followed the suggestion by Scarborough et al. (2004) to explicitly link the projects together to try to enhance the foundation for knowledge sharing between the projects. However, without someone responsible for the co-ordination, this research suggests that explicitly linking projects together and then leaving the teams to share knowledge between themselves is not enough for it to occur effectively.

It was also found that the different cultures and working practices of the different project teams were a barrier to sharing knowledge between them. This barrier was found to be reduced over time, when the project teams got to know one another better. This suggests that building trust over time, through the social interaction of working together, was an enabler for knowledge sharing, as is also identified by Pretorius and Steyn (2005), which allowed the project teams to begin to overcome this barrier. However, given the fairly limited social interaction between the two project teams so far, it was noted that this barrier might not necessarily have been completely overcome yet.

Another barrier to knowledge sharing between the project teams was that each project team wanted to maintain ownership of the knowledge from their particular project. It was suggested that, to overcome this barrier, rules for defining intellectual property rights should be set.

7.4 Extension of the VSM

The theoretical contribution of this research has been to extend the VSM as an analytical tool with which to diagnose cybernetic strengths/weaknesses at the project level of organisations. In Section 2.5, the literature was used to develop Table 7 that highlighted the knowledge required and used by S1 to S5 in the VSM. This table was then used, along with the more traditional VSM analysis approach described by Flood and Jackson (1991), to analyse two project teams. The author believes that, through combining Table 7 with the more traditional VSM approach, it enabled a much more comprehensive analysis of the project teams to be carried out. This resulted in highlighting the relationship between certain different types of knowledge used and shared in project teams, as described in Section 7.2. This would not have been possible through the use of just the traditional VSM analysis approach.

However, the author is aware of certain limitations to the extension of the VSM that this research has developed. These limitations, along with the other limitations of this research, are discussed in the next section.

7.5 Limitations

Tables 7 in Section 2.5 was developed using the current literature on knowledge management in the VSM. There is currently not a great deal of literature in this area and, as such, it is recognised that Table 7 may not be complete in terms of the knowledge required and used within a viable system. As noted in Section 7.6, these tables require a great deal of empirical testing before it can be concluded with certainty that they are complete. Nevertheless, the tables offered a starting point and a guide for the analysis conducted in this research.

It is also recognised that certain other limitations exist in the methods used to derive the findings in this project. As identified in Section 3.4, the microanalysis carried out on the data in this research has some limitations, with the main one being that it leads to the findings inevitably being shaped to some degree by the assumptions and experiences of the researcher (Thomas, 2006).

Due to the Research Fellow in Project Team B choosing not to participate in the interviews, as well as the Facilitator being taken ill and unable to participate in a follow up interview, this led to the research not capturing the complete views of all of the primary actors involved. Nevertheless, the researcher believes that there is enough evidence from the other actors in this research to support the findings that have been made.

There is also a limitation in terms of the generalisabilty of this study. This research aimed to provide the most in-depth analysis possible of knowledge at the project level of organisations. In order to do this, the minimum number of cases possible were focused upon in this research, as increasing the number of cases may have led to diluting the level of depth the phenomenon could be studied in. However, Lee (1989) remarks that single case studies feature unique and non-replicable events, leaving such studies open to criticism that findings may not be applicable to other settings. This limitation is particularly pertinent to the aspect of this study investigating the sharing of knowledge *between* project teams, as there is only one example to draw upon. In the case of studying the sharing of knowledge *within* teams, there will, however, be two examples to compare and contrast, which greatly increases generalisability (Yin, 2003). Nevertheless, the researcher does not suggest that these findings are generalisable to all project teams. Further work that investigates other project teams in other industries is necessary before any such claim could be made.

It is also recognised that the project teams investigated in this research were each less than a year through a 2 year-long project. It is not possible to say whether the issues identified in this research for the project teams will stay the same during the next 15 months, which is when the projects are due to be completed.

7.6 Future Directions

The strength of this research has been to employ a unique, structured approach to analysing knowledge used at the project level of organisations. Prior to this research, the VSM had never before been reported to have been used to analyse the project level of an organisation. This tool of analysis was selected in order to structure the researcher's thinking in this research. It was then extended by developing Table 7 to provide an even more comprehensive tool for analysis. However, these tables require a great deal of empirical testing before it can be concluded that they are complete, due to the limited literature available on this subject. Therefore, the author suggests that more work should be carried out in this area. Specifically, empirical testing should be carried out by using Table 7 to analyse many other project teams, to increase confidence as to whether these tables are complete.

In terms of the practical findings made in this research, the researcher only carried out analysis on two small project teams working on research projects. As identified in Section 7.5, this makes the generalisability of these results questionable. In order to increase confidence in the generalisability of these results, the researcher suggests that other project teams should be studied. In particular, the researcher believes that it would be useful to look at different types of project team, such as:

- larger project teams consisting of more than three members
- transnational project teams consisting of members in different countries
- cross-organisational project teams consisting of members from different organisations

It would then be possible to identify whether these different types of project teams face the same issues as project teams of the type investigated in this research.

As identified in Section 7.5, it is currently not possible to say whether the issues identified in this research will stay the same for the project teams during the next 15 months, when they are both due to complete their projects. For this reason, the researcher suggests that research should be carried out that studies project teams for the entirety of the lifetime of the project that they are working on.

7.7 Summary

This chapter highlighted a number of barriers and enablers found in this research that organisations need to be aware of to increase their effectiveness at the project level. The management implications of these are discussed in the next chapter. This chapter also highlighted the theoretical contribution of the study. The limitations of this study were also discussed, which included limitations through the use of microanalysis and also in the generalisability of the findings. This chapter also identified some possible future directions that research in this area could take. Specifically, these suggestions included empirical testing of Table 7, applying the VSM analysis tool to other types of project team and also analysing project teams for the entire duration of their projects.

Chapter 8

Conclusions

This research set out to answer how knowledge can be managed to help the project level of organisations be more effective in terms of the VSM. This was found to be an area that had not been explored before and presented a gap in the literature. This research bought together three different areas of research, namely knowledge management, project management and systems thinking. The interdependence of these three research areas in this piece of research have contributed to what can be conceived as a new specialism, which tightly links these different research areas together. Despite this interdependence, this research also contributes to each of these different research areas individually and the findings of this research are now summarised in relation to each research area.

In terms of the systems thinking research area, the strength of this research has been to employ a unique, structured approach to analysing the project level of organisations. Prior to this research, the VSM had never before been reported to have been used to analyse the project level of an organisation. This tool of analysis was selected in order to structure the researcher's thinking in this research. The VSM was used as a diagnostic tool to analyse the cybernetic strengths/weaknesses of two project teams with a particular focus taken on the knowledge present or absent in these project teams. This has extended the VSM to encompass the project level of organisations, providing a theoretical contribution of enriching our current understanding of the VSM.

In terms of the knowledge management research area, in Table 7 in Section 2.5 the researcher used the VSM knowledge management literature to identify the knowledge required and shared by the different systems in the VSM. A particular focus was taken in the analysis on identifying the knowledge present or absent in the project teams compared to what the literature suggested there should be, as presented in Table 7. This has contributed to the knowledge management research area by providing a method for assisting in identifying knowledge-related problems at the project level of organisations.

In terms of the project management research area, this research aimed to offer practical help to organisations to improve the effectiveness of their project teams. For this reason, a number of barriers and enablers were identified that organisations need to be aware of to increase their effectiveness at the project level. Drawing on these findings, in order to increase effectiveness at the project level of organisations, it is suggested that organisations:

- Use the VSM to analyse project teams to ensure that S1 to S5 are present and rectify any weaknesses found

- Define a clear vision and set specific interim goals for each project team, although permit these to be modified during the course of the project, if required

The remaining barriers and enablers, presented below, contribute to both the knowledge management and project management research areas. Again, drawing on the findings of this research, in order to increase effectiveness at the project level of organisations, it is suggested that organisations:

- Ensure that project team members are explicitly given time to share knowledge both within and between project teams on a regular basis

- Attempt to increase social interaction both within and between project teams by positioning the locations of where members work in close proximity to one another and encouraging face-to-face meetings to take place, rather than relying solely on information technology to share knowledge. This increased social interaction should enable more detailed knowledge to be shared,

- Explicitly link together projects which show signs of commonality and make someone responsible for co-ordinating knowledge sharing to occur between them

- Define clearly the intellectual property rights of each project team at the start of their project

Despite the limitations identified in Section 7.5, the findings in this research appear to offer some useful insights into knowledge management at the project level of organisations. It is hoped that these insights can be used by organisations to assist their management of project teams, in order to make them more effective in the future.

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