MODELLING CREATIVE TEAMWORK

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Abstract

Understanding team-based creativity is essential for the Information Systems (IS) community. The IS Laboratory (InSyL) at the University of South Australia has established a research project known as CreWS (Creative Work Support) to observe the needs of and subsequently provide ICT support to Creative Teams at work — e.g., strategic planners, software engineers, designers, etc. — involved in the task of solving ill-structured problems.

The primary motivation for this research is that the way in which such problems are currently addressed is, to a surprising degree, poorly understood. Specifically, researchers have found there to be insufficient understanding of creative and collaborative teamwork, which contributes to a lack of diffusion into practice of research outcomes; and consequently there is little effective support available for these teams.

This thesis formed a part of this larger research project, with the goal of observing and understanding Creative Team-members as they collaborated asynchronously in formal places to solve ill-structured problems. Asynchronous collaborative work means collaboration at different times — existing in discussion boards, email communications, etc. — and in the actions of individuals within a larger group context such as commenting on documents and the sharing of information.

We adopted an interpretive, explorative methodology because the area of study is relatively unknown and poorly understood. In the thesis we aim to generate logical theories or models to be examined further using theory-testing methodologies. The empirical analysis comprises structured-case methodology and is guided by grounded case methodology for data gathering, analysis and theory construction. Three related case studies of Creative Teams at work were conducted: the teams were involved in (1) developing a strategic research, (2) applying for research funding and (3) preparing a report to funders on project completion. The results obtained from the case studies were interesting.

In the first cycle of research, we found further evidence that teams work in an evolutionary–consolidating–revolutionary manner: that is, the processes undertaken by this Creative Team, even though at an abstract level, appeared well planned but had episodes of less predictably opportunistic behaviour. Further, there was also a period of review and reassessment, and these findings inform the update of the Catastrophe Cycle Model. In the same cycle we outlined a strategy for the observation and modelling of how a Creative Team functions, designed for use in subsequent case studies.

In the second cycle of research, the findings also hinted at the existence of the evolutionary–consolidating–revolutionary paradigm in Creative Teamwork. While comparing the results between this model and its predecessor, we discovered in addition that in a follow-up stage of a project the peak-to-peak amplitude of the Catastrophe Cycle Model graph was less than that of the initial graph, demonstrating a situation in which the team was exploiting their existing work rather than producing fresh ideas.

In the third cycle, we revisited the model, examining it through the lens of another theory — situated action. Briefly, situated action theory has it that plans are not constant in an overall project framework but change from time to time.

In summation, our research demonstrated that there are distinct opportunistic periods in a systematic planning process, and these opportunistic behaviours need to be considered when developing ICT support for Creative Teams. We showed that these teams work in a non-linear fashion, heuristically guided but unpredictable at a detailed level. Further, a conceptual framework for the working of Creative Teams was developed, which we believe will form a solid foundation for future development of ICT intervention and support for Creative Teams.

1 Introduction

This thesis is a part of a larger research project, CreWS (Creative Work Support), which addresses the design of ICT-based support for Creative Teams — e.g, strategic planning, software engineering, design, military command and control teams — involved in the work of solving poorly- or semi-structured problems.

The work of Creative Teams is characterized by series of group meetings connected by periods in which each team-member performs his/her individual work. The research programme was designed to collect and annotate observational data from both humans and machines when work is performed; as a consequence, a rich picture is obtained of how Creative Teams function at any point in their work. With this clear view we were able to identify the potentially effective ICT support, implement the ICT intervention and then orchestrate the reconfiguration of the ICT-support environment for creative work.

ICT-based support can be utilised for a wide variety of team-based situations: team meetings can be held with participants physically co-located; they can be physically located in a set of meeting rooms linked through ICT; or they can be individually located and connected to other participants, who might themselves be physically located in a set of linked meeting rooms via a PC and ICT connection, for instance. There are also periods of individual activity that can be conceived of as true periods of individual activity or as individual elements within periods of asynchronous collaborative work, and be conducted at a workstation or within a normal office environment.

We categorized the situations as “synchronous, formal place” — conventionally situated meetings or ICT linked meeting rooms; “synchronous, informal place” — informal meetings over coffee; “asynchronous, formal place” — conventional individual work; and “asynchronous, informal place” — individual work calling for ubiquitous ICT support. This range of situations formed the basis for which ICT-based support was developed and orchestrated, and will be described in detail in Section 1.2.

1.1 Problem Definition and Motivation

The research programme focused on developing effective ICT-based support for teams addressing ill-structured problems, often poorly defined and understood, and where little support was then available. In the professional world these problems are pervasive.

Earlier empirical research by Nguyen and Swatman (2003), conducted in the Requirements Engineering (RE) field, concludes that RE processes are inherently emergent and unstructured as opposed to linearly progressive. Initially, Nguyen and Swatman hypothesise that the complexity of the developing requirements model may form a surrogate for the requirements engineer's understanding of the problem under investigation. By recording the RE process using both an ad hoc and a post hoc design rationale notation, and analysing the dynamics of both the complexity of the requirements models and the decision-making record, they identify unexpected patterns of complexity present in the focal artefact (the requirements model) during the learning and design process (see Figure 1-1).

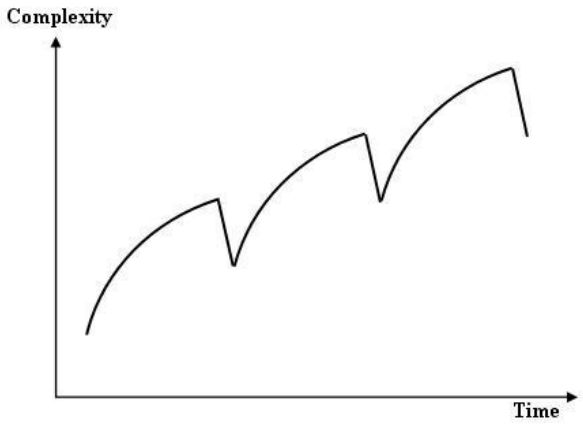


Figure 1-1: Catastrophe Cycle Model

While the nature of Nguyen and Swatman's action research does not lead to conclusive, generalisable results, it indicates strongly that in solving ill-structured problems Creative Teams go through cycles of incremental learning interspersed with periods of insight-driven re-conceptualisation. Several other researchers have also suggested this phenomenon in a range of application domains: examples include the seminal work on creativity by Wallas (1926), as well as Feurer et al. (1996), Lawson (1997), Suwa et al. (2000), etc.

To develop effective ICT support for Creative Teams, we had first to comprehend thoroughly the underlying activities these teams go through while solving ill-structured problems in the real world. We concur with a group of researchers who argue that there is a dire need to understand the dynamics of real world cooperative work (Grudin 1988; Bannon & Schmidt 1991; Bardram 1997). In a classic example of groupware failure in an electronic calendaring system, Grudin (1988) states that one of the factors was a lack of understanding of how groups function. Ackerman (2000) further discusses the need to bridge the gap

between studies of work and design of technology — the "social-technical gap" — in order to develop effective solutions for cooperative work.

Existing literature, however, suggests there is a lack of empirical evidence regarding the impact of the use of current ICT support systems in real world practice (Bannon & Schmidt 1991; Masoodian, Apperley & Frederickson 1995); those few empirical studies available can be found in Robertson (1996; 2000), Muller et al. (2004), etc. Some studies, though useful, make use of artificial problem-solving scenarios (Elam & Mead 1990), and some (Luff, Heath & Greatbatch 1992; Fillipi & Theureau 1993) are able only to suggest general recommendations — in other words, are conducted merely to 'inform' the design of technologies.

To add to this, in reviewing Collaborative Information Technologies (CITs) that support collaborative creative work in organisations, Shumarova and Swatman (2008b) have discovered that existing theories do not translate well into or form a sound basis for the development of ICT support for teams. Because of this, few formal ICT support technologies developed in the research world — other than Lotus Notes and email — have been adopted by teams as well as by organisations. The review was conducted on a combined total of over 900 peer-reviewed articles over the past 30 years: Shumarova and Swatman conclude very definitely that formal CITs do not address relevant problems in teams.

We therefore agree with Bannon and Schmidt (1991)'s argument that not only is a deeper understanding of current activities required, but that the resulting insights must also be useful as leverage for future ICT support. Blackburn (2008) echoes the need to understand Creative Teams because a significant amount of funding has been invested in developing ICT support for them, with little result.

We are not oblivious to the fact that wikis and blogs have recently become more popular and widely-used as communication and collaboration tools in teams. The development of wikis and blogs are largely driven by the open source community and is therefore considered as informal CITs. The scope of this thesis is on formal CITs and and therefore wikis and blogs not discussed at length in this section.

It was essential for us to obtain observational data from real-world Creative Teams that could be translated into effective support. Therefore, we proposed not only to elicit information from the activities that teams undertook when solving ill-structured problems, but

also to develop more concrete models from Creative Teams' problem-solving activities. This would allow effective ICT-mediated support to be designed appropriately.

1.2 Overall Research Programme Objectives and Scope

The ultimate goal of the CreWS project, of which this thesis forms a part, was to enhance the understanding of how Creative Teams function, and to build effective but flexible ICT support for creative teamwork, both synchronous and asynchronous. Creative Team activities are characteristically a network of synchronous group meetings linked by periods wherein members work asynchronously. These activities can be further categorised thus:

- **Synchronous, formal place**. Group meetings in which participants might be: physically co-located; physically located in a set of meeting rooms linked by ICT; individually located and connected to other participants (who might be physically located in a set of linked meeting rooms) via a PC and ICT connection.
- **Synchronous, informal place**. Also termed "coffee-driven collaboration", this covers team-members meeting on the spur of the moment in an informal place, physical or otherwise (e.g., café, bar), wishing to communicate and formulate ideas.
- **Asynchronous, formal place**. Individual activity within periods of asynchronous collaborative work conducted in a formal environment — e.g., on a person's workstation or within a normal office environment. A more comprehensive definition is provided Section 1.3.
- **Asynchronous, informal place**. A hypothetical situation wherein team-members meet, without any work intention, in online chat sessions like Yahoo or MSN Messenger; and suddenly an idea crops up that helps form a creative solution. Some situations, however, require the support of mobile communication equipment and computing, if members need to record as well as share their ideas from moments of individual insight.

Figure 1.2 shows an overview of the research project. At a much more detailed level, the objectives of the research project included, but were not limited to, the development of:

- a requirements engineering-driven approach on how Creative Teams work, fully grounded in observational data and supplemented by post hoc participant interviews. The observations are on the four types of Creative Team activities described above;

- ICT support for teams based on results obtained of the analysis of the observational data;
- a method for evaluating the effectiveness of both creative processes and the ICT-based support implemented as a outcome of an earlier requirements engineering phase;
- an orchestration process controlling the team's operations: auto-configurable, it had to be able to dynamically support any current team activity. Evolution of the orchestration process was to be focused on the team's next predicted activity. This is the final product of the project.

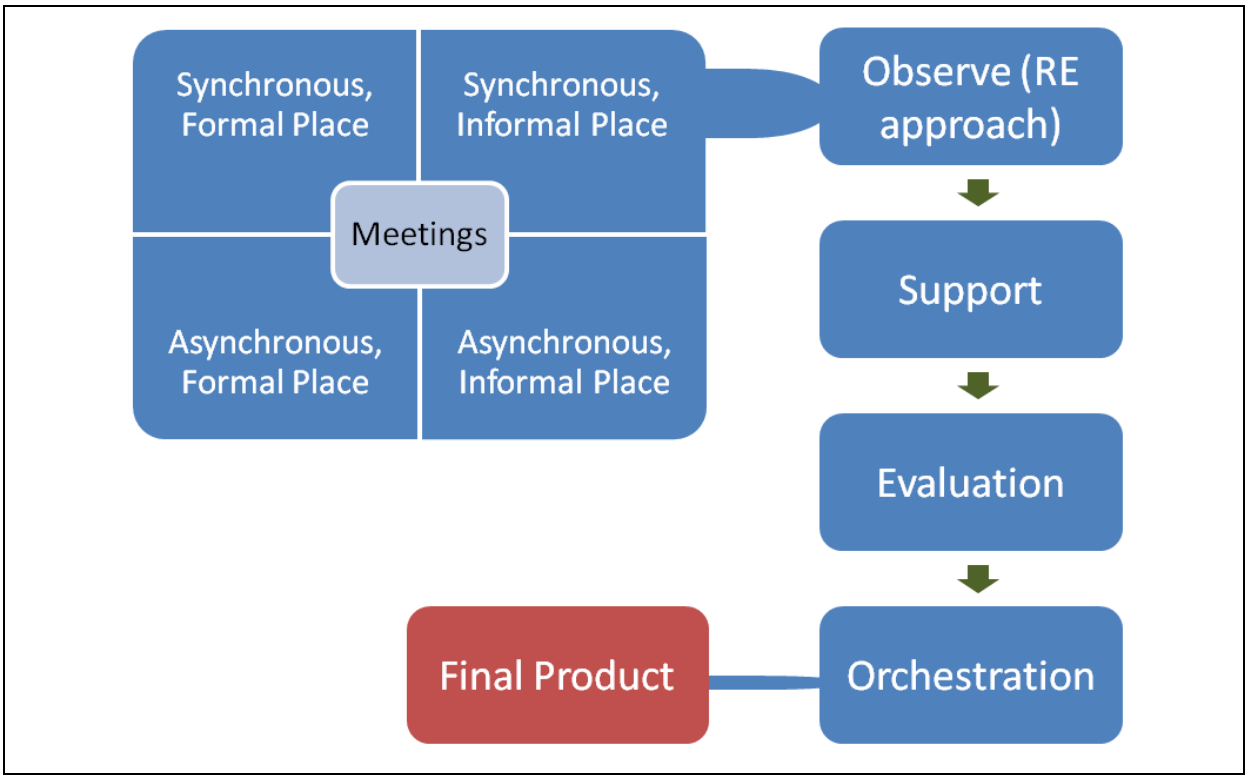


Figure 1-2: Research Project Overview

Because of the massive nature of the CreWS project, it is separated into a series of sub-projects or divisions, of which there are six. Their details are summarised thus:

1. Division 1 focuses on "synchronous, formal place" meetings, monitoring and modelling ICT usage of both individual and intra-group levels,
2. Division 2 focuses on "synchronous, formal place" meetings, monitoring and modelling human activity: the development of artefacts (e.g., specifications, plans, strategies), verbal communication, gaze patterns and non-verbal communication represented within the video record.

3. Division 3 is tasked with extending the work of Division 2 to virtual "synchronous, informal place" meetings; with individual/group work undertaken in conventional settings "asynchronous, formal place"; and with individual/group work undertaken in informal settings, i.e., "asynchronous, informal place".
4. Division 4 focuses on the development of a conceptual schema for the knowledge base within which the ethnographic record is to be stored and made available for later analysis.
5. Division 5 is tasked with understanding the provision of leverage to minimize constraints to Creative Teams and, in particular, the development of requirements engineering and evaluation methods suitable for this context, as well as focusing on orchestration of "synchronous, formal place" and "synchronous time, informal place" meetings.
6. Division 6 is to focus on supporting the achievement of highly creative outcomes.

1.3 Thesis Scope

This thesis is part of Division 3 of the CreWS project: its ultimate aim was to understand team-members as they collaborated asynchronously in formal places to solve ill-structured problems (by "formal place" is meant a place where a team-member had the intention of working, and the place was purpose-designed to support the work undertaken).

It is important to note that the research conducted herein has been foundational research employing an exploratory, interpretive methodology: results that are generalisable are not within its scope. Instead, it generates logical theories/models for future examination using theory-testing methodologies. This issue will be explained further in Chapter 3, specifying the thesis' methodology.

In more detail, the objectives of this thesis are:

O1. To understand the processes of and communications between Creative Team members while they are solving poorly- or semi-structured problems in asynchronous formal place situations.

O2. To understand evolutionary and revolutionary processes of the development of the focal artefact (defined as the central object of a creative process, the product built by Creative Team members) and focal artefact dynamics.

O3. To develop a suitable abstraction or model capable of both representing the above understanding and of providing suitable leverage for future ICT intervention strategies.

All the objectives were pursued in parallel throughout this research. The context of the problem was limited to asynchronous, formal place activities. As an example, a situation wherein a team-member was contributing to a creative team project with a word processor on his laptop: s/he could be located anywhere — a normal office environment, a room or even in a train — as long as s/he was consciously working towards the advancement of the project, and the support (the laptop with word processor) available.

In addition, we wanted to study periods of asynchronous collaborative work: in other words, collaboration that occurred at different times. This type of collaboration could be found in discussion boards, email communications, etc., and in the actions of individuals within a larger group context include commenting, voting, sharing of information and so on.

1.4 Chapter Overview

This thesis is written in seven chapters.

Chapter 1 (this chapter) defines the problem and the overall research programme setup to address it. We have also identified the scope of this thesis and how it fits into the overall picture.

Chapter 2 focuses on the review of the literature on creativity and teams. It also summarises existing ICT-based support for Creative Teams and expands on the need to observe and support them.

Chapter 3 formulates the methodology for this research. It lays down the existing framework of research, and explains in detail the method of data collection and analysis.

Chapters 4, 5 and 6 are the actual data collection and analysis chapters. As will be seen in Chapter 3, this research observed a Creative Teams over the period of 3 cycles: the results obtained from each will be addressed separately in Chapters 4, 5 and 6.

Chapter 7 is the concluding chapter. We summarise the research, and show the final conceptual framework obtained from it. We then discuss the thesis' significance and implications. In addition, we describe the constraints, and future work that could be performed to elevate this research to another level.

We intend that each chapter can also be considered — that is, in addition to being a link in the 'chain' of chapters making up the thesis — on a standalone basis as an item of resource material. It should be noted, therefore, that there will be found a degree of repetition, without which this individual aspect would not be viable.

1.5 Conclusion

In this chapter, we have described this thesis as forming part of a larger, overall research programme aiming to provide ICT-based support for Creative Teams. To reiterate, Creative Team members often have to address ill-structured problems, pervasive in their professional lives. Despite numerous efforts to develop (and funds invested in) ICT-based support for these teams, the outcomes have been at best mediocre. The leaders of the overall research programme and, in fact, numerous other researchers believe that more effort should be invested in studying Creative Teams before successful intervention or orchestration can be developed.

We have also established the objectives and scope of the overall research programme and identified the niche of the research presented in this thesis in terms of the overall picture. Finally, we have presented a chapter-by-chapter synopsis.

The following chapter is the literature review, which forms the foundation of this thesis.

2 Literature Review

2.1 Overview

This section provides a review of the literature of a broad range of relevant subject areas, from the psychological domain of creativity to Information Systems (IS).

A review is made of creativity research, its classifications and the creativity process in general; then creativity is examined through the lens of the Information Systems community. We examine the research performed in the IS community that aimed to support creative teamwork — specifically, the various tools developed to support creative work. We then proceed to identify the gaps in the literature: how theories of creativity and teamwork were, to borrow a phrase from Shumarova and Swatman (2008b), "casually used" when developing systems to support the creative process in the academic world, leading to a lack of impact of such support systems in real-world organisations. This formulated the proposition that the underlying nature of creative teamwork was not understood sufficiently. Finally, through investigating the processes of software engineering teams, we research a series of studies set in motion to achieve this understanding.

2.2 Creativity

Many researchers have found that creativity plays an important role in the contemporary world: for example, Schumpeter (1952) predicted in that year that creativity would be a major driver of the modern economy. Most research into creativity, however, was centred on artistic or aesthetic creativity — e.g., in literature, arts, music, etc. (Amabile 1996; Csikszentmihalyi 1996; Sternberg, R 1999; Kaufman & Baer 2005) — that resulted in placing less emphasis on creativity research in the development of novel products, systems and services. More recently, researchers such as Cropley and Cropley (2005) advocate that creativity should be studied in a more practical context, and fostered as a component of the problem-solving process, especially in the engineering and business environments. Mayer (1999) echoes this by stating that in order for creativity research to thrive over the next 50 years, it must progress towards producing more specified and concrete outcomes, at the same time helping people to understand better the concept of creativity.

As a keyword "creativity" is broad in meaning and covers a wide range of issues; a look at the literature suggests creativity research could be further taxonomised into Creative Outcomes, Creative People and Creative Processes.

2.2.1 Creative Outcomes

Amongst those things distinguishing humans from computers is the ability to produce creative outcomes, so the question here is: what characterises creative output? Several researchers hold a common view that creativity is characterised by the novelty and usefulness of its products or outcomes (Hayes 1989; Hoffmann et al. 2005).

2.2.1.1 Novelty

Novelty is the level of originality or newness found in an outcome; yet several researchers still argue about the degree of novelty that constitutes a creative outcome (Mayer 1999; Törnqvist 2004). A few say that in order for an outcome to be termed 'creative' the thinker must have a breakthrough idea that could considerably alter people's lifestyle, and this idea should not have been thought of earlier; Nobel Laureates fall into this category. Other researchers, however, believe that an outcome is deemed 'creative' if it is novel for the thinker/s, irrespective of the outcome's having been previously discovered or not; and this latter group of researchers has made creativity generally more accessible.

2.2.1.2 Usefulness

It may not be sufficient to claim that an outcome is creative based on the concept of novelty alone: the outcome must also serve a purpose, such as solving a problem considered important by a person or group. In the business context, a creative output must improve the quality of an organisation, its employees and its customers: e.g., when a new product is launched, if it cannot provide added value to the customers it will most probably be rejected in the marketplace. In the engineering context, Cropley and Cropley (2005) reason that creative outcomes must also fulfil functional requirements; they describe this as "functional creativity".

2.2.2 Creative People

Amabile (1989) stresses that the capacity of a person to be creative is guided by his or her domain knowledge, motivation and thinking skills. In arguing about the importance of domain knowledge, Weisberg (1999) claims that important advances deemed 'creative' in a field are made by people with more than 10 years of expertise in that field; Ahonen and Murto (2004) add that people with domain knowledge have essential procedural, technical and intellectual knowledge. In a study on creativity in architectural design, supported by laboratory data, Akin and Akin (1996) state that designers who are creative tend to have a wider range of experience and skills. However, argue Sternberg and Lubart (1993), domain knowledge can

be a double-edged sword, inasmuch as people with knowledge might be more rigid in their imagining with less capability to think out of the box.

Collins and Amabile (1999) state that creative people are often spurred on by intrinsic motivation: because they have that internal drive to succeed and to reach their goals, they may have more opportunities to create something different. Csikszentmihalyi (1991) introduces a concept that he names "the flow of creativity". He mentions that while creative people are involved in demanding tasks, they tend to experience 'flow', a state of intense concentration: e.g., when artists are focused on painting a picture, they can sometimes become unaware of the time and their surroundings, their full capacity being focused on constructing the picture. He states that to achieve this state, one must have these characteristics (Csikszentmihalyi et al. 2005):

- S/he must be a clear sight of the objectives while being involved in a task. This provides both direction and structure to the task at hand.
- S/he must be confident of achieving these goals. To do so, s/he should have a good balance between her/his abilities and the perceived challenges of the task at hand.
- S/he must be able to adapt to any changing demands of the task to maintain the flow state. It helps more if the task at hand can provide effective feedback.

He subsequently mentions that we may need to provide a suitable environment for flow to occur, so that creativity can be induced (Csikszentmihalyi 1999).

Other researchers such as Ahonen and Murto (2004) believe that creative people have appropriate thinking skills, and that these skills determine the approach that they take to solve problems. Ward et al. (1999) believe that creative thinking skills consist of both generative and exploratory approaches: the generative approach concentrates on indexing, retrieving and transforming available information, for example, while the exploratory involves searching for useful ideas or evaluating usefulness.

2.2.3 The Creative Process

Creativity is a vital part of the problem-solving process (Cropley & Cropley 2005). Lubart (2001) defines the creative process as a succession of actions that produces a unique idea or product. In this thesis, creativity has been seen as a series of activities where team-members aim to progressively develop a focal project artefact, culminating in meaningfully solving the problem that the team first set out to solve. Support for teams engaged in the creation of novel

products had to address the elements of creative interaction and collaboration among their members.

The classic 4-stage creativity model (Wallas 1926) often used as a basis for research into creative processes specifies four stages: preparation, incubation, illumination and verification. In the preparation stage, a person should explore the problem domain vigorously and systematically. During the incubation stage, the person moves away from the problem for a while and lets his subconscious take over the thinking process; it is often argued that by doing so he or she may obtain new perspectives on or approaches to how to solve the problem. Illumination, sometimes known as "the 'Aha!' moment", usually occurs unexpectedly, and is a product of both incubation and preparation: the mind involuntarily forms a good idea for solving the problem. Finally, during the verification stage, the person then validates the idea and finds out whether or not it solves the problem.

2.2.4 Creativity and Ill-structured Problem-solving in Teams

Creativity is a vastly complex process that cannot be easily dictated and defined (Goldenberg, Mazursky & Solomon 1999). A number of researchers maintains that it is difficult to evaluate the creativeness of a product immediately after a problem is solved. For example, Nakamura (2000) reasons that the value of creativity can only be judged over time, and that measuring the value itself is complicated. Hayes (1989), by citing the example that Gregor Mendel's work was not recognised until centuries later, explains that there is subjectivity in the expert judgements made of creative activities. Hargadon and Sutton (1997) state that creative solutions rarely arise when we need them; and that even if they do emerge, they are seldom recognisable or adaptable.

How, then, do we design suitable support systems for creativity if a valuable solution can only be evaluated effectively some time after a product has been created? Fisher (2000) believes in 'little-c' creativity — that is, creativity in everyday work practice. He suggests, and we agree, that understanding creativity in the context of everyday activities is important in increasing productivity. In addition, we believe that creativity in everyday work practice also involves a step-wise approach in solving ill-structured problems; and that creativity and ill-structured problems are inextricably linked.

Ill-structured problems are those without immediate goals or constraints; their representations are dynamic, and the solutions produced cannot be credibly evaluated (Coyne 2005). Many researchers claimed that identifying and structuring the problem properly is

almost as difficult as if not more difficult than solving it: as identified by Hayes (1989), for instance, a cognitive factor that affects creative activities is a person's ability to choose and represent his/her problems properly. He adds that being aware of the possibilities of improving a satisfactory situation is equally important; not just "digging out of trouble" as is implied in problem-solving.

In addition, support for teams engaged in creative or ill-structured problem-solving processes must address not only the creativity of the individuals, but also the elements of creative interaction and collaboration among team-members. The management of creativity in an organisation is done by synchronising different kinds of creativity across different work domains to achieve successful outcomes (Basadur 2005).

In the context of this thesis, creativity was a series of activities where team-members aimed to progressively develop project artefacts, culminating in meaningfully solving the ill-structured problem they set out to solve. Therefore, in our view, a team was to be considered creative if its members initially looked for a problem, constantly defined and redefined the ill-structured problem found, came up with potential solutions and eventually solved the problem. We examine this closely in the following sub-section.

2.3 Exploration versus Exploitation[1]

The creativity process is explored further in a seminal work by March (1991), who describes at length the concepts of exploration and exploitation in organisations. In the exploration phase, researchers or organisations frequently experiment with new methods to establish new paradigms, novel ideas or solutions; whereas exploitation focuses on refinement and extension of pre-existing paradigms, ideas or solutions. Gilsing and Nooteboom (2006) describe exploitation in organisations as a form of consolidation into an influential product offering, which in turn results in market stability and increased consumer demand: to compete better in this mature market environment organisations shift their focus from providing further product innovations to improving their business processes — e.g., enhancing their production and distribution mechanisms.

[1] The concepts of exploration and exploitation will be re-visited in Chapter 5 (one of the mini-literature review sections): the reason for the content at this point is the smooth flow created when it is read in conjunction with the concepts of creativity discussed above.

March (1991) also points out that once a researcher develops new ideas and experiences success with those ideas, s/he will try to exploit the ideas that brought success in the first place rather than create new ideas. For example, Art Fry, the inventor of the Post-it Note, created other products — the Post-it Pop-up Note Dispenser and the Post-it Flag — that revolve around his original idea.

> Success in generating an idea that is new and useful decreases exposure to new ideas and encourages the use of heuristics that worked in the past. The creative process may actually be path dependent; once an individual generates a creative idea, future creative efforts may be framed from the perspective of the initial idea. (March 1991)

In addition, most inventions are less inclined towards problem-finding and more towards problem-solving; in other words, inventors are more interested in exploiting existing ideas. To illustrate this point further, Audia and Goncalo (2007) study the development of inventions in the hard-disk drive industry through an analysis of patenting history of major hard disk manufacturers, and observe that successful researchers are less inclined towards exploring new domains of research: rather, they prefer to build on their current knowledge base, so that their ideas tend to be more incremental than divergent in nature. Audia and Goncalo (2007) also argue that incremental ideas "have less impact in their field", based on the frequency with which these ideas are cited by the community.

The question can be put: "Will there be a negative effect if organisations focus too much on exploitation, rather than on exploration?". According to some researchers (March 1991; Gilsing & Nooteboom 2006), the answer is yes, it will be detrimental, especially in the long run: an organisation devoid of new ideas is considered technologically bankrupt, and could potentially be overtaken by newer entrants more agile and adaptive to market conditions.

Conversely, Lee et al. (2003) present another perspective on this issue: some organisations can actually prosper by exploiting available technology rather than by exploring/adopting a superior strategy. If the organisation has a large customer-base accustomed to a particular technology, a better but different technology may not appeal to them. An example provided in the literature is Intel: in the 1990s, Intel chose to use the established complex instruction set computing (CISC) technology rather than the more advanced reduced instruction set computing (RISC) technology in their processors because their customers were too familiar with the older technology.

Do we explore uncertain but possibly more advantageous solutions, or do we exploit established but potentially less effective solutions? As a result of this tension between both exploration and exploitation paradigms, when we study the creative process of teams we should not only evaluate the novelty of the solution itself, but also observe how much existing knowledge the team has utilized, and the difference between the team's output and its previous achievements.

2.4 Teams

A team is a number of persons associated together in work or activity (Merriam-Webster Online Dictionary), and they are, typically, united with common objectives. Members of a team come from different backgrounds and have different skills, and will therefore have the capacity to generate diverse ideas/efforts to further the team's goals. Teamwork refers to the activities performed within a team to achieve the goals. The spectrum of activities of a team ranges from playing football to writing a research paper. The number of people in a team, depending on the nature of the task-in-hand, can also vary widely. The size of the team can impact on the outcomes produced by the team as a whole. Blanchard, Randolph and Grazier (2007) believe that to function optimally, an ideal team is made up of four members.

Mode	**Description**
Independent	Each member of the team acts independently but can be supported by other members in the team; e.g., a badminton team
Interdependent	The outcome of the teamwork depends on the contribution of each member in the team; e.g., a football team
Self-managed	Teams using clear boundaries with freedom and responsibility in making effective decisions; e.g., inter-departmental meetings in organisations
Project teams	These are formed for a specific purpose and for a limited time
Virtual team	A group of interdependent members distributed geographically across different time zones
Creative team	A group of people collaborating in intense and time-sensitive work that involves instant decision-making and planning; e.g., air traffic control

Table 2-1: Team modes

Tables 2.1 and 2.2 show the different modes and work contexts a team may take. However, the purpose of the tables is to provide an overview on how a team may function. A

team usually works in a fluid manner, and may shift from one mode to another or one context to another. For example, members of a team may be distributed geographically, but they may decide to have a face-to-face meeting at some point of time, and therefore collaborate synchronously.

Context	Description
Co-located	Participants are physically located and the teamwork may occur at a designated place like a meeting room with ICT support; e.g., face-to-face board meetings
Distributed	Team members are geographically distributed in different time zones but collaborate from their respective work environments; e.g., project meetings with team-members from different branches of a company located in different States
Formal	Team members meet at a designated place such as a meeting room to collaborate in making decisions and the intention for the team to collaborate is at maximum; e.g., board meetings
Informal	Team members collaborate in casual situations and in informal locations such as coffee shops where technology support can be minimal; e.g., breakfast meetings: although there is no intention of formal collaboration, a novel solution may appear during the communication of ideas over the table
Synchronous	Team members collaborate at the same time within any of the contexts discussed thus far; e.g., weekly project meetings, which can also be either co-located or distributed
Asynchronous	Team members collaborate in different time dimensions but are still contributing to the common team goal; e.g., the mode of collaboration can be email conversations

Table 2-2: Work context categories of teams

A variety of contextual factors may influence the creativity of teams. For instance, Shalley and Gilson (2004) explained broadly that the factors may fall on several levels - individual, social and organisational levels. On the individual level, an individual in the team has a combination of different personality, expertise, motivation, cognitive ability compared to that of his teammates. Andrews and Smith (1996) added that an individual's problem-solving ability which includes his/her knowledge and experience, as well as intrinsic motivation and compulsion of risk-taking is a contributing factor to the creative level of a team. On the team

level, the dynamic interations between the team members as well as the diversity of the team (e.g. ethnical and cultural diversity) influences the level of creativity exhibited by the team. Finally, on the organisational level, an employee's job characteristics, role expectations, resources available to him/her influences his/her contribution in a team environment, and subsequently the creativity of the team.

2.5 Supporting the Creative Process in Teams

The IS community has long acknowledged that an understanding of team-based creativity is essential in many aspects of the domain. Within IS, researchers from diverse disciplines — including but not limited to Group Decision Support Systems (GDSS), Computer Supported Cooperative Work (CSCW), process mining and Human Computer Interaction (HCI) — have taken an interest in studying team creative processes as well as developing a selection of tools to support these processes.

2.5.1 Group Decision Support Systems

Group Decision Support Systems (GDDS) are interactive ICT-based systems that assist team-members discover solutions to ill-structured problems, normally found in the formative stages of collaborative processes; amongst the more successful is one from researchers at the University of Arizona (Nunamaker et al. 1997), which centres on supporting the decision-making process using computer systems. Most GDSS impose strict rules on the decision-making process, causing it to be structured and, typically, involving cycles of brainstorming, grouping, evaluating, voting and prioritising (Fjermestad 2004; Arnott & Pervan 2005; Rains 2005). The taxonomies of GDSS can be found in the work by DeSanctis and Gallupe (1984), who classify them based on degrees and duration of decision-making and physical co-locations of group members; and the work by Kraemer and King (1988), who classify GDSS based on their underlying technology.

GDSS aimed originally to encourage participation from all team-members, provide process structures for decision-making and expand organisational memory/knowledge base from meeting to meeting (DeSanctis & Gallupe 1984). Recent work on GDSS has focused on assisting groups in technology selection (Torkkeli & Tuominen 2001), evaluating journals (Turban, Ma & Zhou 2004) and detecting deceptive communications (Deokar & Madhusudan 2005). To further demonstrate the viability of GDSS, several researchers have conducted field studies on its implementation over 15 years in different organisations — International Business Machines (IBM), Boeing Aircraft Corporation (BAC), Nationale-Nederlanden

(NN), and European Aeronautic Defence and Space company, Military Division (EADS-M) (de Vreede et al. 2003). From these studies, the authors found that the biggest advantage of GDSS has been timesaving for IBM, BAC, EADS-M, and a higher quality of meeting outcomes for NN.

However, there are limitations within GDSS research. For instance, Talbott (1995) argues that researchers are too concerned with developing and improving GDSS algorithms and do not consider the wider socio-political context in which the GDSS is situated. By following blindly mechanical procedures, he argues, we may inhibit human relationship and creativity rather than support it. He believes that at times critical insights occur unexpectedly at the end of a process, and may invalidate the ideas that preceded them. This idea is supported by Mandviwalla and Gray (1998) who claim that researched tasks "do not correspond well with complexity, experience and political situations faced by people in organisations". Furthermore, existing GDSS ignore individual decision-making processes and patterns of information exchange between individuals that will eventually affect the quality of collective decisions during group meetings (Danesh & Jin 1999; Troyer 2003), as well as avoiding an earlier step in ill-structured problem-solving approaches — that of recognising the problem and generating the context for problem evaluation (Bannon 1997).

Most GDSS research focuses on the earlier stages of creative team processes, especially on the brainstorming and idea selection stages. Decision-making is usually assisted by the system's providing templates, flagging potential issues for evaluation, providing statistics, suggesting action and taking pre-programmed actions to mitigate detected issues (Wainfan & Davis 2004). Application examples of GDSS include assisting groups in technology selection (Torkkeli & Tuominen 2001) and evaluating journals (Turban, Ma & Zhou 2004). In recent years, researchers have attempted to create Web-based GDSS with similar underlying principles, except for using the Web as a platform (Bharati & Chaudhury 2004; Bhargava, Power & Sun 2007).

2.5.2 Computer Supported Cooperative Work

The idea of Computer-Supported Cooperative Work (CSCW) was first disclosed by originators Irene Greif and Paul Cashman at a workshop in 1984. It is, in Greif's own words, "an identifiable research field focused on the role of the computer in groupwork" (Greif 1988). The field was initially set up to explore how people work together and interact with information resources under computer technology mediation (Greif 1988, p. 6). Greif also

mentions in her book the importance of investigating the effects of technology in groups — that emphasis must be not only on technology, but also on people. Bannon and Schmidt (1991) agreed that CSCW needs to address both social and technical aspects of cooperative work. They maintain that we need to understand how people really work, and this understanding is critical in ensuring the acceptance of new technologies and systems. The CSCW domain has its origins in two fields of IS research — Human Computer Interaction and office automation (Crabtree, Rodden & Benford 2005). Schmidt and Bannon (1992) note that research in these areas has started to appear with more regularity under the banner of CSCW.

The core issues in the domain of CSCW are ever-expanding, and there has been debate on what constitutes CSCW. However, it is widely recognised that a significant sub-theme of CSCW is research in groupware, a technology used to support teamwork (Penichet et al. 2007), which includes applications such as collaborative authoring tools, online discussion areas, file-sharing facilities and integrated calendaring systems. Grudin (1988) cites a number of examples of what he perceives as problems in groupware research: he argues that in reducing the workload to one person, an application may require additional labour from another person or group of people. One of his examples concerns digitised voice applications; it may make the communication task easier for the speaker, he writes, by allowing him or her to speak instead of to type, but it will increase the workload of the listener as s/he has to listen to the whole voice recording to extract the relevant information. Further, digitised voice cannot be scanned in the same way that text can, resulting in the difficulty of reviewing and/or correcting voice messages; and greater storage is needed for voice clips than for text messages.

As an example of collaborative writing software, Noel and Robert (2004) designed a tool, a detailed online questionnaire that obtained feedback from 41 people — primarily from the very scientific and academic domain that was involved in collaborative writing. They concluded that specialised collaborative writing software was rarely used and that "writing with a groupware tool was the exception rather than the norm". They also cited a number of studies on the effects of collaborative writing tools, to reinforce their findings. We believe this points up the pressing need for ethnographic field studies into people solving real-world problems to facilitate the development of new 'gadgets'.

However, in practice CSCW research has a relatively narrow ethnographic foundation. There are few publicly-available detailed ethnographic data sets of any sort, although

ethnography has been a popular approach for data capture (Bentley et al.1992; Hughes, Randall & Shapiro 1992; Hughes et al. 1994; Pycock & Bowers 1996; Pettersson, Randall & Helgeson 2002), which may be due to the fact that such data sets are time-consuming and expensive to create. A few examples of ethnographic field studies in CSCW are discussed in the following section.

The CSCW community as a self-defining entity appears to have emerged from the 1984 workshop to focus on the role of computer systems in group work (Crabtree, Rodden & Benford 2005). Creative problem-solving research in CSCW is relatively limited, as most research is driven by social influences, human factors, explanatory theories for informing tool design or ICT-based support (Neale, Carroll & Rosson 2004; Crabtree, Rodden & Benford 2005). The term 'groupware' describes a specific technology in CSCW that is used support teamwork (Penichet et al. 2007); common groupware applications include collaborative authoring tools, online discussion areas, file-sharing facilities, integrated calendaring systems etc., as mentioned earlier. Another area in CSCW that is useful in supporting the creative process is process mining, stated initially in Van Dongen et al. (2003)'s study on groupwork and workflow management systems. It is essentially a bottom-up approach, in that by collecting event logs (work data in real time), an organisation is able automatically to build a workflow model.

2.5.3 Awareness

In the CSCW field there has been a number of studies providing some appealing insights into types of data that could be collected as well as into ways to collect and analyse them. For example, Begole et al. (2002) develop tools to help collect and analyse users' computer activities and the location of these activities, as well as their online calendar appointments. The aim is to discover work activity patterns in teams, and pinpoint convenient times when team-members can contact each other. The study is carried out on three distributed groups: themselves (5 members), affiliated researchers (4 members) and a distributed support team (9 members). They use the Awarenex prototype, developed in earlier research (Tang, Yankelovich & Begole 2000; Tang et al. 2001), to collect minute-by-minute computer interaction logs (mouse/keyboard activity) from users' workstations; and a proxy is installed between team-members' email clients and servers to obtain data on email activity.

Their research provides visual indicators as to the potential periods of time a user can be reached electronically, and promotes awareness of information in a team-member's online

calendar and his or her email-reading pattern. In subsequent research, Hill and Begole (2003) reveal how they built a predictive and descriptive model of temporal patterns from the record of one individual's computer activity; this model can now be used to predict when a user will be present in a workplace and, if the user is present, predict when s/he will leave it.

Perhaps the most interesting data collection and analysis techniques are proposed by van der Aalst et al. (2005): the researchers position process mining as a potential research topic in CSCW, because social networks and process models can be discovered from electronic work being carried out. Section 2.5.6 will further discuss process mining.

2.5.4 Empirical field studies in CSCW

Bowers (1994) elaborates on Grudin's argument that users of a computer system have to put in extra effort in order for it to function properly. He noticed this phenomenon during a field study on the implementation of a computer network in a British government organisation that involved interviews and participant observation over an 18-month period. However, he cautioned that this study should not be taken as a failure of CSCW systems but, rather, that it makes explicit the extra overhead on users involved in the implementation of new systems.

Robertson (1996) conducted a descriptive field study over a period of seven months on a small, distributed team of eight people, involved from start to finish in the design of multimedia educational software. The results were quite basic, in that the efforts the designers put in to communicate with each other enabled the cooperative design of the software. Robertson believes that if future technologies are to be developed, they must support the team in easing the efforts of complex collaborative work processes. These technologies, however, should be flexible and not process-oriented, in line with the work context of this software design team. To further elaborate on her findings, Robertson (2000) develops a taxonomy of actions performed by the software designers, individually as well as within the team. She believes that in doing so, more specific information can be provided to CSCW developers, and hence the gap between workplace studies and computer system development narrowed further.

Bardram (1997) presents an interesting way to conduct ethnographic field studies with a focus on re-designing existing systems. In performing a series of field studies, he compares and contrasts work procedures using the Green System, an existing computer-based system in Denmark, within hospitals that are not using it. Specifically, through participant observations, interviews, document analysis and other techniques, he identifies five strategies that might

assist in collaborative activities in hospitals; with these strategies in mind, he then conducts another set of field studies on hospitals that are using the Green System, and identifies its weaknesses to inform the system's re-design.

The importance of conducting ethnographic field studies before commencing technological design is emphasised by Fjeld et al. (1999)'s report on the design of a collaborative tabletop system based on activity theory. The system, named "BUILD-IT", was invented "based on state of the art computer vision technology", and was targeted as a design planning tool. The system revolves around the idea of manipulating actual bricks, using both hands on a tabletop: by doing this, the users are able to control virtual objects projected by the system on the tabletop and on another screen to the side of the table. The researchers assumed that the users would be able to interface more naturally with a brick than with a mouse/keyboard interface.

However, a later report by Lauche (2005), one of the researchers of the BUILD-IT project, questions the usefulness of the brick-based interface. She argues convincingly, based on results from field studies, that the prototype from this project could not be turned into a successful commercial product. Although empirical field studies into the nature of work on this project and many others have been conducted, Lauche claims that they only started after the design process began. She says:

> ...yet in this case (and indeed many similar ones) the design process had already started and the empirical research was almost ornamental in terms of its status and resources (Lauche 2005).

Her belief that empirical field studies should be conducted to gain critical insights into collaborative work and that the development of supportive tools should only be conducted after the field studies needs to be explored further.

2.5.5 Human Computer Interaction

Human Computer Interaction (HCI) researchers study how humans and computers perform tasks in conjunction, and are specifically involved in studying the capacity of humans in operating computers, how humans interact with computers and how best to design and implement computer interfaces. The HCI domain originated from the initial CADCAM systems, the first interactive computing systems in the world to mandate electronic collaboration between man and machine. If we look further back to Sutherland's 1963 thesis on the discipline of computer graphics (Hewett et al. 1996 p.3), research in the HCI domain

traditionally examined a single human interacting with a computer; but gradually research in this field diffused into the investigation of teams of people interacting with electronic systems in general (Blackburn 2008). Recently, multiple studies were conducted into virtual worlds: e.g., how people interact with each other through a Massively Multiplayer Online Game (MMOG) such as World of Warcraft (Ducheneaut et al. 2006); this kind of research serves to provide a foundation for technological support to be designed at a later stage.

There is also a body of research involving the application of creativity and cognitive theories in the HCI discipline, with an intense focus on empirical research into the activities of creative people and the computational modelling of creative cognition (Candy & Hori 2003). Examples of tools that are designed as a result of the research into creativity in HCI include a text-editing software for people in the early stages of writing (Yamamoto & Nakakoji 2005), a flexible image manipulation software that allows users to easily reverse their actions (Terry & Mynatt 2002), and a tabletop and 'roomware' system that enables better communication (Warr & O'Neill 2007).

2.5.6 Process mining

The concept of process mining is found initially in van Dongen and van der Aalst (2002)'s work. They state that workflow management systems use a top-down approach to designing workflow systems; so a designer must not only be familiar with the computer language used for designing the workflow system but s/he must also have a thorough understanding of the work processes in the organisation for which the workflow system is being designed. A potential solution to overcoming this difficulty is provided by the researchers — process mining. Process mining is essentially a bottom-up approach, in that by collecting event logs (work data in real time), an organisation is able to build a workflow model automatically from these event logs. To facilitate the collection of data as well as the modelling of workflow, a process mining software named 'EmiT' has been developed by the researchers. Specifically, they obtained an event log from 'Staffware', one of the more popular workflow management systems at that time, then translated the log into XML format, ran the XML format through EMiT, and finally built a process model of the events in the form of a Petri net.

Dusdar and Hoffman (2005) built on van Dongen and van der Aalst's work by extending process mining tools to analyse ad hoc processes, or "processes that have no underlying process definition". They argue that at times people and organisations in the real world function in an ad hoc fashion, and there are instances where "teams work on processes

without modelling them in advance". These unstructured processes should be understood by using process mining tools to ensure future support. Originally, the researchers were already using a pre-developed groupware named 'Caramba', which has the capability to create event logs; EMiT was then used to generate a process model and a social network from these event logs.

2.6 The need to understand creative teamwork

Despite the various attempts coordinated by the IS community to support creative work, there is still much room for improvement. A wide variety of GDSS studies has been conducted, but recent commentators (Lin, Geng & Whinston 2005; Poston 2005; Wasko & Faraj 2005) point out that much remains to be done in developing effective solutions, especially in terms of technology support and cultural consideration (Bannon 1997; Saunders, Van Slyke & Vogel 2004). A review by Fjermesdad and Hiltz (1999) of 230 experiments involving these systems in refereed conference proceedings as well as in reputable journals reveals that there is not much of a difference in face-to-face methods when compared with the use of systems. The positive effects are lacklustre and, in fact, disappointing.

Further, some researchers find that in practice, CSCW research is founded on a relatively narrow ethnographic foundation. Examples include Lauche's critique on the BUILD-IT project (Lauche 2005), that revolves around the idea of manipulating actual bricks on a tabletop with one's hands, enabling a user to control virtual objects projected by the system on the tabletop and on another screen to the side of the table.

Ackerman (2000) points out that there is a "social-technical gap" in CSCW research. In one sense, he explains, what is needed to be supported in groups is far from what can be supported technically: the "social requirements" of CSCW are well behind its "technical mechanisms", he argues.

Shumarova and Swatman (2008b) perform a thorough study on the diffusion of Collaborative Information Technologies (CITs) that enhance collaboration in organisations. CITs are a field in their own right, and encompass some of the domains mentioned in section 2.5 — e.g., CSCW and GDSS.; and collaboration software such as email and Lotus Notes falls under the CIT domain. What they find is interesting is that very few CITs appear to be formally grounded in established theories of team behaviour. Shumarova and Swatman (2008b)'s results from an extensive content analysis of CIT literature indicate that only 47 of the 400 articles studied referenced one or more fundamental theories. They examine the use to

which theory was put within these 47 papers: in 37, which may be classified as 'casual' users of theory, a list of citations to theory was given in the introductory sections of the paper, but no apparent use was made of the material. In only eight papers, drawn almost entirely from the special issue on activity theory in the Journal of CSCW (this having skewed the results), theory informs the presentation of material. Finally, two papers represented reviews; and these could be classed "theory only".

Secondly, formal CITs lack impact within organisations. An extensive content analysis was made of CIT literature conducted by organising and classifying past research, especially that pertaining to the adoption, use and diffusion of CITs across and within organisations. The content analysis covered more than 500 articles published in peer-reviewed journals during the last three decades. Only 33 papers (~6%) could be classified as studies of the adoption and use of CIT: only one paper was found that could be classified as addressing the diffusion of CIT innovation (Lewis, Bajwa & Pervan 2004).

Shumarova and Swatman (2008b)'s base argument is that in practice formal CITs fail to contribute to organisations because they do not address relevant problems or do not address them in culturally appropriate ways. Blackburn (2008) supports this point by reporting in his dissertation that there is a need to understand Creative Teams, as research into computer support for these teams:

> …has had almost no impact on organisations in spite of significant investment in time and money… {and} …the only applications with any profile are email programs and Lotus Notes (Blackburn 2008).

There is an urgent need to collect and analyse further empirical data in real-world Creative Teams as well as to apply existing theories of creative teamwork as the foundation for the design of technology to support the work.

We agree with the Kaplan et al. (1997), who state that

> real progress in enhancing the usability of collaborative systems hinges on improving our understanding of work, and applying the resulting insights to development of collaborative work support frameworks (Kaplan et al. 1997).

Ackerman (2000 p.185) also calls for researchers to explore, understanding that the social-technical gap in CSCW must be heeded because it represents one of the key challenges in

CSCW research. We agree that more needs to be done to understand collaborative teamwork, and our approach is to do so through empirical observation.

2.7 Role of Requirements Engineering in Understanding Creative Teamwork

We support Farooq et al. (2005)'s opinion that in order to support the creative process, it is important to elicit requirements from the process itself. Indeed, recent studies in the requirements engineering (RE) domain (Nguyen, Swatman & Shanks 1999; Nguyen & Swatman 2003) lead to a conceptualisation of the RE process as an inherently creative one. Nguyen and Swatman have frequently presented to professional requirements engineers the characteristics of their RE process model. Their first step is to ask a requirements engineer to describe the process taken in any RE task; the engineer describes the process as systematic, similar to the initial plan of the project, and this description is consistent with existing theories in requirements engineering. However, when Nguyen and Swatman probe the issue further by asking if the engineer ever has moments of inspiration when performing the task, s/he is often surprised by being able to recall the event where reconceptualisation of the task occurred — not unlike Nguyen and Swatman's initial observation.

The creative process, according to them, is comprised of periods of incremental learning or evolution (E) interspersed with periods of creative opportunism or insight (I), which results in the reconceptualisation of the problem space (R). This concept is represented by the Catastrophe Cycle Model (Figure 2-1).

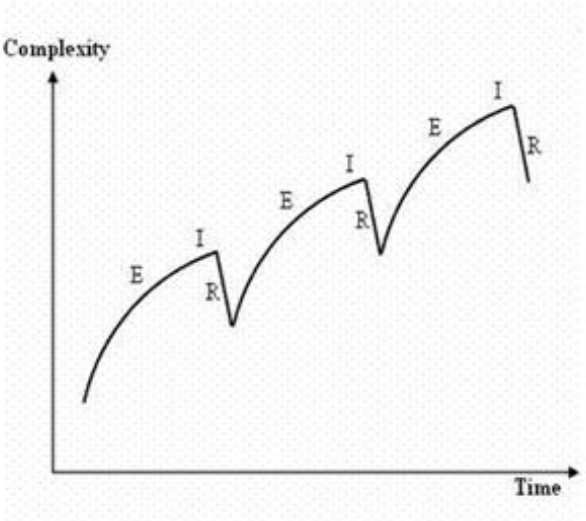


Figure 2-1: Catastrophe Cycle Model

The diagram refers to a focal artefact, or main output object, that people work on throughout a project. In Nguyen and Swatman's case, the focal artefact takes the form of a requirements diagram (Nguyen, Swatman & Shanks 1999; Nguyen & Swatman 2003): the vertical axis represents the complexity of the focal artefact, or the level of information contained in the artefact, while the horizontal axis represents increments of the project time.

In Figure 2-1, the initial stage (point E) is known as the evolutionary stage and consists of semi-structured activities, at this stage mainly centred on information gathering and processing, and putting into the focal artefact. The creative aspect is when one mentally analyses the information: the complexity of information being processed is ever-increasing up to the point where the graph reaches point I. At this stage — also known as the incubation period — complexity will be high, despite the graph's plateauing; and the activities can be described as a categorising of the ideas. Creativity is evident at the insight phase points I and R, when the complexity will reach the peak of the evolution-revolution cycle and finally crash to R. The 'revolution' occurs because the final solutions will suddenly be more visible and apparent, and unneeded content removed from the focal artefact. The revolution space requires less mental processing as complexity is decreasing; less cognitive effort is required to re-conceptualise the final candidates for inclusion in the model. The process is less formal and/or structured. The researchers claim that creativity is apparent because of the build-up of the focal artefact document until the point of saturation, where its authors will achieve insight and rethink their ways of solving the solution stage, and in the process trim down the output so that the solution fits better its original, intended objectives.

The insights gained from their research are an outcome arising from use of an immersive, observational and participatory research approach, which underlines significant weaknesses in traditional requirements elicitation and modelling approaches when applied to the investigation of unstructured problem contexts. We believe that this pattern of behaviour is frequently more generally displayed in ill-structured or creative work.

2.8 Chapter Summary

From the literature, we believed that creative processes are quite similar to ill-structured problem-solving processes and that they should be supported. The domains of GDSS and CSCW were explored because they both deal with collaborative groupwork. We found that studies in GDSS aim to support the generation and storage of participants' ideas as well as knowledge in meeting rooms. CSCW, however, has a broader focus, where technology to

support collaboration needs to be incorporated into a wider social context. Nonetheless, we have shown that there is a lack of empirical field studies in this area, although most researchers believe them to be critical in the development of technological support tools for teams.

In addition, we found within the creativity and requirements engineering literature that people do not follow an entirely linear path towards achieving their work goals. At some point they may encounter difficulties and from there obtain opportunities for change. In fact, in the requirements engineering literature we found a unique model, the Catastrophe Cycle Model (CCM), which shows that a requirements engineering team (in this case, also a Creative Team) follows an evolutionary–revolutionary path towards achieving its goals.

Our search into CSCW field studies provided us with the notion that observation and interviews are useful avenues for data collection, albeit in a more social context. On the other hand, process mining studies provide valuable insights into technological aspects of data collection; for example, we are able to collect electronic data such as emails, files and so on from creative team-members. Not only can we capture the content of such documents, we could also know when the documents were stored and who stored them.

We discussed, earlier in Chapter 1, that the objective of this thesis is to understand team-members as they collaborate asynchronously and in "formal places" to solve ill-structured problems: Chapter 2 has established the foundation for this research by delving into the related creativity and teams literature — existing support systems (or lack of them) for Creative Teams, their importance and, finally, a potentially useful model that could assist in the teams' understanding. Also, we explored the literature on communication and processes of teams and team working contexts (which relates closely to thesis objective O1), and the evolutionary and revolutionary processes of focal artefact development in the form of the initial Catastrophe Cycle Model (research objective O2).

With this in mind, we proceed to Chapter 3, which will show a variety of methodologies in IS research. From there, the philosophical approach as well as the methodology of the thesis will be presented.

3 Research Design

3.1 Introduction

Chapter 3 introduces the design of this research project, starting with an overview of Information Systems research that includes discussion on qualitative and quantitative research methods and also positivist, interpretive and critical research epistemologies. A discussion and comparison of the different taxonomies of IS research methods by Neuman is added, to enhance discussion. Further, key research methods such as grounded theory, case study research and structured-case methodology are presented. Finally, we present the research design of this thesis, from its philosophical perspective to the data collection and empirical analysis. The theory development deals with three related studies of Creative Teams at work: (1) the development of a strategic research, (2) an application for funding for this research and (3) the preparation of a report to funders upon completion of a project. The empirical analysis comprises both grounded theory and structured-case methodology, for data-gathering, analysis and theory construction. The chapter concludes with the underlying assumptions and limitations of the thesis.

3.2 Information Systems Research: an Overview

In recent years, Information Systems (IS) research has been going through a continuing transformation process, from being solely technologically-oriented towards achieving a more socio-organisational context (Clarke 2001; Myers & Avison 2002). IS academics and practitioners have begun to conduct research that extends their focus to include technical, organisational and behavioural issues (Myers & Avison 2002; Hirschheim 1992; Galliers 1992). A researcher needs to be aware that the underlying philosophical assumptions of research influence its direction and strategy; and philosophical assumptions related to the underlying research epistemology are of particular importance (Myers & Avison 2002).

The development of the IS research paradigm has resulted in a broader range of research methods and an increased use of qualitative research (Kaplan & Duchon, 1988; Hirschheim & Klein 1989): this is in line with Galliers and Land (1987)'s recommendation that research methods must take into account the nature of the subject matter and the complexity of the real world.

The use of qualitative techniques in IS research is today widely accepted and seen as enhancing the effectiveness of IS implementation within organisations, as well as enabling effective assessment of the impact IS has on individuals or organisations (Galliers & Land 1987; Russo & Stolterman 2000). The qualitative approach to analysis offers a variety of interpretations of the same phenomenon; and can provide existential insight into IS implementation (Shanks et al. 1993; Russo & Stolterman 2000). In this thesis, we undertake a qualitative research approach that uses an interpretive underlying epistemology. The following subsections will introduce briefly the philosophy that underlies qualitative research.

3.2.1 Quantitative vs Qualitative Research

A common method of classifying research paradigms is to differentiate between quantitative and qualitative research methods. Quantitative research originated from natural sciences (Myers 2002), and was developed to identify causal relationships (Lu 2006). This approach to research involves the use of methods such as laboratory experiments, formal and numerical methods (mathematics and econometrics) and sample surveys to collect empirical data (Myers 2002). The approach is mostly outcome-oriented, where the results can be counted.

Qualitative research, on the other hand, originated from social sciences with the purpose of studying complex social and cultural phenomena. Qualitative research methods include action research, case study research and ethnography and are often used in the IS domain (Lu 2006; Lee 1999). Data for qualitative studies can be obtained from fieldwork (participant observation), interviews and questionnaires, documents and texts, and the researcher's impressions and reactions (Myers 2002). One of the important factors of qualitative research is for the researcher to understand the world in which the participants live, as well as the social and cultural context of that world. Hence, experienced researchers such as Kaplan and Maxwell (1994) emphasise the importance of qualitative research, and are of the opinion that the understanding of phenomena from the perspective of humans within a socio-cultural context would be mostly lost if textual data was to be quantified.

Neuman (2003) provides an excellent summary of the key characteristics of quantitative and qualitative research approaches, which is shown in Table 3-1.

Quantitative Research	Qualitative Research
Testing is carried out on the hypothesis the researcher begins with.	Meaning is captured and discovered once the researcher becomes immersed in the data.
Concepts are in the form of distinct variables.	Concepts are in the form of themes, motifs, generalisations and taxonomies.
Measures are systematically created before data collection and are standardized.	Measures are created in an ad hoc manner and are often specific to the individual setting or researcher.
Data are in the form of numbers from precise measurement.	Data are in the form of words and images from documents, observations, and transcripts.
Theory is largely causal and is deductive.	Theory can be causal or non-causal and is often inductive.
Procedures are standard, and replication is assumed.	Procedures are particular, and replication is very rare.
Analysis proceeds by using statistics, tables, or charts and discussing how what they show relates to hypotheses.	Analysis proceeds by extracting themes or generalisations from evidence and organising data to present a coherent, consistent picture.

Table 3-1: Characteristics of quantitative and qualitative research approaches (Neuman 2003)

Qualitative research can also contain positivist, interpretive as well as critical approaches (Hirschheim 1992; Guba & Lincoln 1994); and a combination of research approaches is often referred to as 'triangulation' (Kaplan & Duchon 1988).

3.2.2 Positivist, Interpretive and Critical Research Epistemologies

Another popular way of classifying research paradigms is to divide them into the positivist, interpretive and critical research categories. It is important, however, to note that quantitative research does not immediately equate to positivist research; nor is qualitative research equivalent to interpretive research.

The underlying epistemology of the researcher and his/her personal philosophical assumptions determine whether or not the qualitative research s/he is conducting is interpretive, for example (Myers 1997; Klein & Myers 1999). Some researchers have taxonomised qualitative research, based on the underlying epistemology, into positivist,

interpretive and critical categories (Chua 1986), as shown in Figure 3-1. This taxonomy is extremely popular with IS researchers, because each provides a distinct and interesting approach to observe, measure and understand the world (Myers 2002).



Figure 3-1: Underlying philosophical assumptions (adapted from Myers 2002)

3.2.2.1 Positivist research

Positivist research has its roots in traditional scientific approach. Using this paradigm, researchers assume that there is a reality that can be objectively observed, and the characteristics of this reality can be measured independently of the researcher and his tools (Myers 1997). Orlikowski and Baroudi (1991) state that in positivist studies, researchers attempt to "test theory" and "increase the predictive understanding on phenomena". They identify the characteristics of positivist studies, and argue that one such should generally contain

> evidence of formal propositions, quantifiable measures of variables, hypotheses testing, and the drawing of inferences about a phenomenon from the sample to a stated population (Orlikowski & Baroudi 1991).

Other characteristics of reliable positivist studies include repeatability, reductionism and refutability (Ng-Kruelle 2006; Checkland 1981; Checkland & Holwell 1988), determinacy ("the truth is out there") and prediction ("the use of knowledge claims in the form of generalisations") (Garrick 1999).

3.2.2.2 Interpretive Research

Interpretive research has its roots in phenomenology and hermeneutics (Boland 1985), and has emerged from recent years as a viable alternative within the IS community to positivism. The key differentiating factor between interpretive and positivist researchers is that the former assume reality to be constructed by social means and interactions, created by shared meanings and experiences in a group of people (Myers & Avison 2002), while traditional positivist research encompasses concepts such as determinacy and prediction; repeatability, reductionism, refutability (Checkland 1981 p.13) — which, as many researchers argue, is inadequate in truly representing the phenomena of the social world we live in. In particular, Garrick (1999, p. 149) points out that humans are interactive with the social world (or the world they live in): they can make individual judgements and decisions that can alter social phenomena. He states that "all human actions are meaningful", contributing to the ever-changing dynamics of the world.

The interpretive research epistemology is most effective in complex and pluralistic contexts, such as the study of social and organisational phenomena. Interpretive researchers undertake an approach that places a higher emphasis on human involvement in the creation of reality, and advocates that different people may interpret in different ways the same situation. Kaplan and Maxwell (1994) state that there are no pre-defined variables in interpretive research, since it focuses on human reflexitivity throughout the emergence of a situation. Therefore, interpretive studies should be framed contextually (Garrick 1999), in that they must reflect the social connections and environment we live in. Olikowski and Baroudi (1991) agree, and further state that

> evidence of a nondeterministic perspective where the intent of the research was to increase understanding of the phenomenon within cultural and contextual situations; where the phenomenon of interest was examined in its natural setting and from the perspective of the participants; and where researchers did not impose their outsiders' a priori understanding on the situation (Olikowski and Baroudi 1991).

Candy (1991, p. 432) identifies five other common assumptions of interpretive researchers regarding this epistemology:

1. an event or action is explainable in terms of multiple interacting factors, events and processes; causes and effects are mutually interdependent;
2. there is a significant difficulty in achieving complete objectivity, especially in observing human subjects, who function on their individual systems of meaning;
3. the objective is to develop an understanding of individual cases, rather than universal laws or predictive generalizations;
4. the world is made up of tangible and intangible multi-faceted realities, best studied as a whole rather than in fragments of dependent and independent variables, so that the significance of the context in which the experience occurs is recognised
5. inquiry is always value-laden, and this will inevitably influence the framing, focusing and conduct of research.

In the IS domain, Walsham (1993) stresses that interpretive researchers must be concerned with the context of the information system, as well as how both system and context influence each other. In this epistemology, there are no pre-defined dependent and independent variables (Candy 1991), but special focus on the complex world of human sense-making when situations emerge (Kaplan and Maxwell 1994).

Other interesting discussions on interpretive research include:

- a review of the pros and cons of interpretive research (Garrick 1999; Goulding 1999),
- the ethical issues in interpretive research (Stahl 2005),
- the principles of conducting interpretive research (Klein & Myers 1999), and
- the problems of using only one epistemology or paradigm (positivism) in IS research (Goles & Hirschheim 2000).

3.2.2.3 Critical research

Critical research, also known as critical social theory in sociology, assumes that social reality is historically constituted, and continuously produced and reproduced by people (Myers 1997). It is strongly influenced by theories such as structuralism, post-structuralism, deconstruction and Marxist theory, and encompasses many related developments in literary theory and cultural studies, aesthetics, theoretical sociology and social theory, and continental philosophy (Ng-Krulle 2006). Juergen Habermas is one of the champions of critical research in the modern era: one of his major contributions is on “the public sphere”, a common realm where people can have freedom to discuss issues that affect society.

The difference between this and positivist and interpretive research is that it is strongly oriented towards radical social change (Ng-Kruelle 2006). Critical researchers argue that people are able to alter their social and economic situation, but their ability to institute change is heavily restricted by social, cultural and political domination. They therefore aim to expose restricting and alienating conditions of the status quo, as well as to take steps to eradicate the causes of alienation and domination (Myers 2002). In the IS domain, critical research is able to promote understanding of research issues at the macro level (Myers 2002; Klein and Hirschheim 1994). Olikovski and Baroudi (1991) state that through its application well-formulated, entrenched assumptions about organisations and information systems are examined with a critical eye. Researchers perform a dialectic analysis of the research context in which "the historical, ideological and contradictory nature of existing social practices" is shown (Orlikovski & Baroudi 1991).

3.2.3 Taxonomy of research methods by Neuman

According to Neuman (2003), research methods can be classified into three perspectives: exploratory, explanatory and descriptive. Table 3-2 summarises and illustrates the goals of each of these three categories of research approach.

Goals of Research		
Exploratory	**Explanatory**	**Descriptive**
Become familiar with the basic facts, setting and concerns.	Provide a detailed, highly accurate picture.	Test a theory's predictions for Principle,
Create a general mental picture of conditions.	Locate new data that contradict past data.	Elaborate and enrich a theory's explanation.
Formulate and focus questions for future research.	Create a set of categories or classify types.	Extend a theory to new issues or topics.
Generate new ideas, conjectures, or hypotheses.	Clarify a sequence of steps or stages.	Support or refute an explanation or prediction.
Determine the feasibility of conducting research.	Document a causal process or mechanism.	Link issues or topics with a general principle.
Develop techniques for measuring and locating future data.	Report on the background or context of a situation.	Determine which of several explanations is best.

Table 3-2: Neuman (2003)'s classification of research methods

3.2.3.1 Exploratory Research

In exploratory research, the problem domain is not well-defined. Kotler et al. (2006, p.12) emphasise that the key goal of exploratory research is

> to gather preliminary information that will help define problems and suggest hypotheses (Kotler et al. 2006).

In other words, an exploratory researcher's purpose is not to seek direct solutions, but to look for ideas and generate specific questions that could potentially be addressed in the future.

Research of this type often starts in a relatively unexplored domain: in a way, the researcher plays the role of explorer, and conducts feasibility and pilot studies in that domain. The end result is familiarity with and an insight into the subject area, as well as a solid foundation for the design of subsequent research studies.

3.2.3.2 Descriptive Research

In descriptive research the aim is to describe the phenomena that exist and to deliver an accurate account of the specific details of a situation. The focus is on how? and who? questions, such as “How did it happen?” and “Who is involved?” (Neuman 2004).

Descriptive research makes an excellent follow-up to exploratory research because it makes use of already-generated questions and drills deeper into the problem by examining and explaining the nature of the issues faced. It can potentially inspire an entirely new explanation of the subject area.

3.2.3.3 Explanatory research

This is often used as a follow-up to both descriptive and exploratory research.

An explanatory researcher investigates the source of social beliefs, behaviours and conditions; s/he documents causes, delivers reasons and tests theories. This approach attempts to clarify why and how a relationship between two aspects of a situation or phenomenon exists: in what way(s) does variable 1 influence variable 2? — e.g., “why is the introduction of empowerment seen as a threat by departmental managers?” and/or “how can the number of complaints made by customers be reduced?”. Complete understanding of the cause-effect relationships between the phenomena is the focus of this approach.

Quantitative and experimental designs and methodologies are often used for conducting explanatory research.

3.3 Research Methodology

A research methodology is much more than merely employing a simple suite of methods; it also contains philosophical foundations, assumptions and beliefs that underpin the research conducted. In fact, Myers (1997) maintains that a research methodology is an instrument that provides researchers with

> a strategy of inquiry which moves from the underlying philosophical assumptions to research design and data collection (Myers 1997).

A sound and flexible methodology is required for the research into Creative Teams.

A method is selected based on the objectives of the research. Various forms of evidence can be collected, and the method is tightly linked with the objectives; for example, a distinction can be made between theory-building research (description/explanation) and theory-testing research (explanation/prediction) — each requiring an entirely different form of evidence. The selection of a research strategy will revolve around the nature of the research as well as the aims of the researcher (Benbasat 1984; Benbasat, Goldstein & Mead 1987). There is a wide range of research practices, skills and assumptions that can influence the particular research methods chosen (Myers 1997). In the following sections we will discuss different research methodologies closely related to the purpose of this thesis, ranging from grounded theory to the structured-case.

3.3.1 Grounded theory

Initially developed by Glaser and Strauss (1967) in the sociology domain, grounded theory has now become one of the more common methods used in IS research (Myers 1997). The goal is to discover a theory that assists in the understanding of a research domain (Heath & Cowley 2004).

In this approach, there is no clear distinction between the data collection and data analysis phases (Suddaby 2006); instead, these phases are interwoven — the researcher must "constantly compare" new data collected with analysis previously conducted to gain a better understanding of the research area, until theoretical saturation is achieved (Qureshi et al. 2005).

There is significant interplay between induction and deduction: induction is essentially bottom-up, where a researcher observes phenomena and tries to find recurring patterns in the observations; then formulates a hypothesis that leads, after exploration, to the formation of theories. On the other hand, deduction and verification are top-down: after forming theories, the researcher then deduces and verifies whether or not these theories are true. In this sense, "deduction and verification are the servants of emergence" (Heath & Cowley 2004). The induction–deduction interplay goes on until constant theories emerge and there is little or no new knowledge to be gained.

In grounded theory there are no hypotheses at the beginning of the research: from the data ideas are induced to formulate mini-theories (McGhee et al. 2007). The researcher then collects further data to assess whether the mini-theories could sufficiently describe the phenomena observed. Constant collection, interpretation and reinterpretation of the data cause the emergence of concept categories that in turn lead to the formation of a concrete theory: here the researcher's creativity plays an important role, as s/he has to determine what the categories are based on through the data obtained. It is important to note, though, that the categories must be grounded in the data, and must not be based on the researcher's preconceived notions or personal bias (McGhee et al., 2007). Because there are no discrete sequential data collection and analysis phases, researchers must maintain caution when using this approach, to avoid close description or illumination of their methods (McGhee et al. 2007).

Substantial examples of grounded theoretical studies on groups of people can be found in the literature — e.g., Turner (1983) and Orlikowski (1993). Using three separate case studies, Turner (1983) elaborates on how he and other researchers applied grounded theory:

1. The researcher observes and analyses the development of relationships between nurses, their patients and the patients' relatives.

2. He is actually involved in the second case, which focuses on factory production systems in their social contexts. The researchers induce nine organisational features of batch production systems and, in addition, identify the causes that shaped these features in the first place.

3. The last is more catastrophic in nature: he draws on mainly documentary sources to examine the pre-conditions of 84 man-made disasters. Through grounded theory analysis, he finds a core feature in all cases: disasters that involved distributed groups of individuals solving complex, ill-structured problems. He then extends it into a model of man-made disaster pre-conditions.

Orlikowski (1993)'s research was assisted greatly by grounded theory in investigating the deployment of technology, or CASE tool, in a complex organisational context.

3.3.2 Action Research

Action research involves the detailed investigation of problems/issues in a context, where the researcher has an active involvement in the context itself — i.e., the researcher "becomes a

partner in the action and process of change" (Wood-Harper 1985). In a way, the researcher is involved both in instituting change (action) and in achieving understanding (research) at the same time (Dick 1999).

There are many interpretations of the action research process; perhaps one of the more detailed processes comes from Susman (1983). His book provides us with five distinct steps of the process in each study, shown in Figure 3-2:

1. Firstly, the situation is diagnosed to identify issues/problems.
2. Next, all potential courses of actions are listed.
3. After careful consideration, the best action is identified and implemented.
4. Then the researcher collects and analyses the data on the results of the implemented action.
5. S/he then interprets the findings to discover if the intervention is effective.

The process is then repeated continually until the problems are addressed.



Figure 3-2: Action Research Model (Adapted from Susman (1983))

3.3.3 Case study research

The case study research method is a way of empirically investigating a contemporary social phenomenon within its environmental context, where the relationship between phenomenon and environment is not clearly known (Yin, 2002). A case study is an intensive description and analysis of an event, a programme, an individual, a group, an institution or an organisation (Whitman & Woszczynski, 2004).

In which circumstances do we apply the case study research method?

Sankaran and Tay (2007) propose a model recommended by Yin (2002) and adopted in the management research domain (Carson et al. 2001). The situations described in the model include the time when:

1. There is a lack of current knowledge about the issue
    - The literature review shows there are knowledge gaps
    - This indicates new theory needs to be built;
2. The phenomenon being studied is complex
    - Researcher needs to understand the full context
    - Researcher needs a rich understanding of the issues;
3. The phenomenon is contemporary and dynamic;
4. Multiple sources of evidence can be used.

A case study research has more depth when compared, for example, with a survey approach. It allows a researcher to examine phenomena in detail under the natural circumstances in which they exist. Case studies are often exploratory in nature and offer researchers significant flexibility to analyse and address situations and events as they emerge. A case study could either be used to discover a new theoretical concept or to present new input to an existing domain of research (Whitman & Woszczynski, 2004). Therefore, it is particularly useful to present a new set of hypotheses for future research.

A summary of the characteristics of case studies by Benbasat, Goldstein and Mead (1987 is shown in Table 3-3.

Key Characteristics

1. Phenomenon is examined in a natural setting.
2. Data are collected by multiple means.
3. One or few entities (person, group, or organization) are examined.
4. The complexity of the unit is studied intensively.
5. Case studies are more suitable for the exploration, classification and hypothesis development stages of the knowledge-building process; the investigator should have a receptive attitude towards exploration.
6. No experimental controls or manipulation are involved.
7. The investigator may not specify the set of independent and dependent variables in advance.
8. The results derived depend heavily on the integrative powers of the investigator.
9. Changes in the site selection and data collection methods could takes place as the investigator develops new hypotheses.
10. Case research is useful in the study of 'why' and 'how' questions because these deal with operational links to be traced over time rather than with frequency or incidence.
11. The focus is on contemporary events.

Table 3-3: Case Studies Key Characteristics (Benbasat, Goldstein & Mead 1987 p.371)

Another important aspect of the case study research method is its capacity to describe relationships (Galliers 1992) and change. Because most case studies are undertaken over a longitudinal period of time, the researcher is provided with the tools and the structure to observe important events as they emerge.

Detailed and rich data can be captured from case study research. Case study data can be obtained from various sources, including documents, archival records, interviews, direct observation, participant observation and physical artefacts (Yin 2002).

It is to be noted that case study research can be positivist (Yin 2002, Olikowski and Baroudi 1991) or interpretivist (Walsham 1993).

3.3.3.1 Positivist CSR

According to Yin (2002), a scientific approach is recommended for case study research. For him, a multitude of experiments can be conducted in each case in the form of observations, interviews, records, etc. — similar to laboratory experiments, but in a real-life setting. The main point that positivist case study researchers try to emphasise is that a researcher observes

facts, not the interpretation of them; and should thus not be directly involved in the situation being observed (Braa, 1995).

To illustrate this further, Sankaran and Tay (2007) explain that the positivist case research approach usually contains these seven steps:

1. Conduct a literature review to develop a theory.
2. Design the research.
3. Prepare a case or multiple cases or embedded cases.
4. Write individual case reports (for multiple cases or embedded cases)
5. Conduct cross-case analysis.
6. Modify developed theory based on the findings.
7. Identify policy implications.

3.3.3.2 Interpretivist CSR

In contrast, the interpretive approach to case studies is concerned with gaining understanding.

Interpretive researchers often argue that interviews and observations are hardly neutral, due to the fact that those observed may alter their behaviour: this is often described as "the Hawthorne effect" (Schwartzman 1993). In addition, different researchers may have differing interpretations of the same facts. The best a researcher can do in conducting a case study is to try to minimize the impact s/he has on the situation. Walsham (1993) contended that one should not aim for generalisation in a case study approach, but to achieve understanding of the situation being observed.

3.3.4 Structured-case methodology

Due to the diverse range of research methodologies available to an IS researcher, Carroll and Swatman (2000) introduced the structured-case research methodology, that provides an organised framework in which a variety of processes and tools can be chosen to construct theory.

> Structured-case not only helps in performing the research, but also documents the links between the research themes (in the conceptual framework), data (observations and interpretations in the field), the data analysis (coding using the concepts in the conceptual framework, and emergent themes) and the theory and knowledge accumulated through the research process (the series of conceptual frameworks) (Carroll and Swatman 2000).

The structured-case methodology has its roots in action research and case study research methodologies: the key factor that differentiates structured-case from action research is the researcher's perspective. He or she using action research aims to participate in the project being studied but, at the same time, to make an academic contribution (Kock 2004). Although the researcher is actively observing the subjects, at the same time s/he directly intervenes to further the goals of the project the subjects are involved in. Conversely, in structured-case the researcher aims to distance him/herself from the subjects. However, some form of interaction is allowed, unlike traditional case study research, wherein contact with the subjects is discouraged because of the risk of 'contaminating' the data: with structured-case the researcher may, for example, ask for clarification on certain events that happen to the subjects during a project.

This qualitative-interpretive research methodology is mainly used in poorly understood research domains and is particularly useful for building a thorough understanding of the phenomena (see, e.g., Ng-Kruelle 2006). Structured-case is particularly effective in providing a systematic organisation of our research approach.

Another major differentiating factor between structured-case research and general case-based research is its iterative nature. Although both approaches are concerned with theory building in a poorly-understood domain, structured-case advocates the initial formation of a formal conceptual framework; as the research progresses with the collection and analysis of data, the conceptual framework will be continuously redefined or updated until there is no new knowledge to be gained. With this constant refinement, tightly coupled with proper documentation, the dynamics of the research domain can be captured effectively (Carroll and Swatman 2000). As the problem domain is explored step by step, the researcher 'spirals' iteratively towards an understanding of the domain (Figure 3-3):

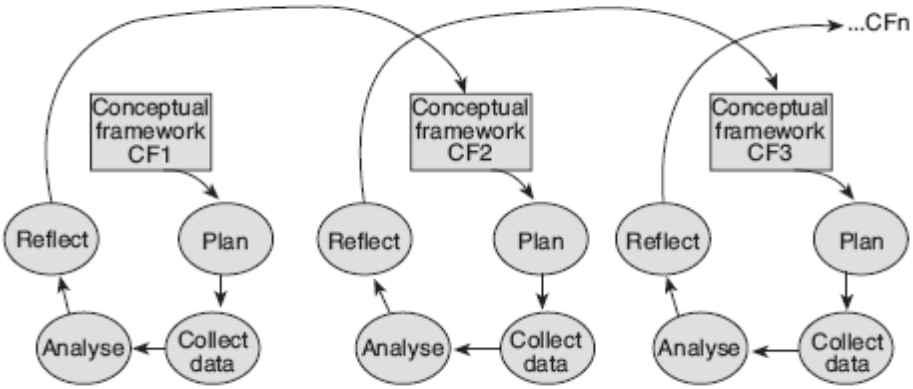


Figure 3-3: Structured-Case Methodology A (Carroll & Swatman 2000)

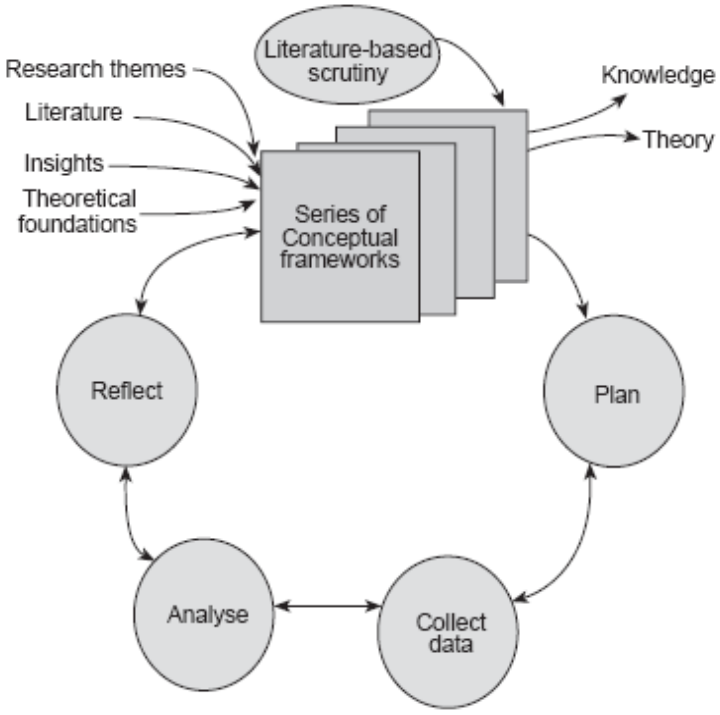


Figure 3-4: Structured-case Methodology B (Carroll & Swatman 2000)

Figure 3-3 offers a closer look on the structured-case methodology. Delving deeper into this approach, Caroll and Swatman (2000) state that the structured-case contains three main elements:

1. a formally-defined conceptual framework that describes the key topics to be examined;
2. a research cycle that includes cycles of planning, data collection, analysis and reflection;

3. theory construction, supported by literature-based scrutiny of the theory constructed.

As shown in Figure 3-3, the researcher enters the problem domain with an initial conceptual framework in mind (CF1), which is shaped by his/her understanding of the research domain prior to entering the cycles. Having completed a cycle and gained new knowledge of the research area, the researcher will compare the analysis of the data with the existing framework, conduct further literature review and refine the initial model. This leads to a new conceptual framework (CF2), which then forms the his/her pre-understanding of the second cycle. A sequence of conceptual frameworks (CF1–CFn) is produced, with each new version of the conceptual framework (CF) as a refinement of its predecessor: CFn is the most current version of the theory formulated. The researcher will carry on with this process spiral until "theory saturation" is reached, where s/he discovers that there is little knowledge to be gained.

This an ongoing refinement of the initial research framework and not unlike the constant comparison approach proposed by Glaser and Strauss (1967) to grounded theory.

3.4 Thesis Research Design and Justification

To provide a deeper insight into the research design of this thesis, this section will describe in more detail the steps we have undertaken in conducting the research.

As mentioned in Chapter 1, the thesis forms part of a larger research project to study Creative Teams (CreWS project), to provide effective support and orchestration for these teams. Its key objectives are:

1. to understand the processes of and communications between Creative Team-members while they are solving poorly-structured or semi-structured problems in asynchronous formal place situations;
2. to understand evolutionary and revolutionary processes of focal artefact development and focal artefact dynamics;
3. to develop a suitable abstraction or model that is capable of both representing the above understanding and providing suitable leverage for future ICT intervention strategies.

The thesis was initiated during the beginning of the CreWS project, so it was from its outset exploratory work on how teams work in the formal, asynchronous domain. The

maximum scope was to develop a logical model that could be further examined in the future with theory-testing methodologies.

An interpretive epistemology will be adopted to study the phenomenon. The interpretive stance assumes that the understanding of reality can only be achieved through social constructions (Myers 1997; Klein & Myers 1999) and in IS, researchers aim to understand

> the context of an information system and the process whereby an IS influences and is influenced by the context (Walsham 1993; Myers 1997; Klein & Myers 1999).

We take this approach because we believe that members of Creative Teams are unable to effectively articulate the processes they follow/have followed, either individually or collectively, in solving the unstructured problems that face them (Ford et al. 1991). Additional challenges include the fact that processes, roles and indeed, goals that cannot be fully defined at the commencement of the project become potentially both fluid and emergent.

In addition, this thesis adopts a qualitative stance. Qualitative research methods, which include case studies, ethnography and action research, provide a rich picture of the socio-cultural phenomena within the subject. In our case, the behaviour of Creative Teams and their social interactions were indeed complex, and deeply embedded in the context from which they undertook tasks that were, by their very nature, hard to quantify.

Attempts to quantify social and cultural phenomena have thus far not produced satisfactory results, because the context is lost when data are quantified (Kaplan and Maxwell 1994). Neale et al. (2004, p. 114) mention that the quantitative paradigm "has served as the underlying knowledge base for CSCW systems" for quite some time. Researchers have also argued that observation of CSCW must extend over a longer period of time; for example, while a person's use of a spreadsheet can be observed in a single hour, collective collaborative interactions typically unfold over days or weeks (Shumarova 2009). Andersen et al. (2003) state researchers are now more receptive to the idea that using qualitative research techniques can help enhance IS implementations. Shumarova (2009), in fact, argues that the focal point of analysis has changed

> from physical ergonomics, to information processing at the interface to the broader framework of behaviour and interaction rich with complexity (Shumarova 2009).

Drawing on the above interpretive-qualitative philosophical stance, we will use grounded theory as a guide for this research work. Orlikowski (1993) perhaps describes its features most accurately by characterising grounded theory as inductive, contextual and processual. We follow on her line of reasoning that a major feature of grounded theory is that it is an inductive theory-discovery mechanism firmly based on empirical observations. In our research situation, while we admit that models of the creative processes do exist in the literature, we argue that these models are quite general, and few grounded in empirical field studies that accurately reflect the ways in which Creative Teams work. The characteristics of grounded theory will assist us in abducing a theory from (a) the artefact dynamics; and (b) both the process and communication data, in a formal, asynchronous, team-based context. Accordingly, the theory developed will also be sufficiently detailed to allow ICT interventions at specific moments of time in the creative problem-solving process.

In order to produce practical results in grounded theory, several researchers argue that

> the complexities of the organisational context have to be incorporated to understand the phenomenon, rather than to be simplified or ignored (Martin & Turner 1986; Pettigrew 1990; Orlikowski 1993).

We conceptualise Creative Teams as small organisations of people and, naturally, grounded theory fits well with studying the complexities of these teams.

Finally, grounded theory facilitates

> the generation of theories of process, sequence and change pertaining to organisations, positions and social interactions (Glaser & Strauss 1967, p. 114; Orlikowski 1993).

It is a research method that potentially incorporates the components of process, progression and dynamics; therefore it can be employed to study the changes in team actions and behaviour, as well as the alterations of the artefact, for the duration of a creative process.

The second methodology we draw upon is the structured-case, which is used to organize our research. This methodology is used because it is highly adaptive and iterative in the theory-building process. It is also important because it offers a way to move from data to theory, highly relevant to practice (Caroll & Swatman 2000, p. 239). In addition, there are other benefits that can be derived from the structured-case methodology:

- it provides us with "a rich and convincing explanations of findings", well documented as well as grounded solidly in collected data (Carroll & Swatman 2000, p.239);
- it fits the interpretive stance of the thesis, as the researcher is not constrained to apply statistical comparisons between data collected; but the methodology is effective when used in theory-building based on deep understanding.

As in Figure 3-3, we conducted three distinct cyclical field studies on Creative Teams at work. We entered the research cycle (Entry Point) with a general idea of the problem as well as a very broad examination of the existing literature, as reported. We argue that in this research context, it was not feasible to go into the field blindly; however, we took care not to let the ideas from the literature constrain our thinking as research progressed.

The basic premise of grounded theory is that the researcher should aim to collect the data that best characterise the phenomena under study, unconstrained by existing literature and/or any of its assumptions. In fact, this point has been so frequently stressed that some researchers were labouring under the misconception that they should not be referring to any literature at all. Glaser (1992, p. 32), in his later work, clarified that

> scholarship in the same area {should} start after the emerging theory is sufficiently developed, so the researcher is firm on his discovery and will not be forced or preconceived by pre-empting concepts (Glaser 1992, p. 32).

This is similar to the structured-case, wherein a conceptual framework is defined at the beginning of the research project, based on an initial literature review.

The integration of both approaches provides us with a potentially powerful yet flexible way to explore how Creative Teams function. Grounded theory allows for inductive reasoning: the data collected can be blended in the context in which teams work. With structured-case, the research can be organised into structured, cyclical studies — each distinct in its own way yet interconnected with the other cycles.

In this thesis, while a preliminary survey of applicable literature (Chapter 2) was undertaken to help maximize our data-collection channels, a more specific literature search was conducted upon completion of each research cycle. Following the premise of both grounded theory and structured-case, the literature is to be continuously re-examined and incorporated as new understanding of the research themes emerges. The 'mini' literature review at the end of each research cycle was vital in helping us develop a sufficient

knowledge base for the empirical analysis conducted in that cycle; it helped identify existing knowledge and important achievements in this research field as well as the gaps in this body of knowledge, and also helped to find potentially contrasting views (Bourner 1996).

Based on Figure 3-4, there are four thesis stages to be followed in sequence for each cycle: Plan, Observe, Analyse and Model. The first stage involves the planning of the types of data to be collected, the tools that are to be used to collect the data, the methods for analysis and the data modelling techniques; the methods used for data capture and analysis in field studies will be further elaborated in Section 3.3 and 3.4 respectively. In the second and third stages we observe Creative Teams, collect data and analyse them based on the methods specified during the planning stage. Lastly, during the final stage we either build a model of the data we have collected and analysed, or we review the model developed during the preceding cycles. Similarly for the literature review at the end of each cycle, based on the data that have been modelled: we identify the types of literature needed, read the literature, analyse it and finally compare and contrast the findings with the model. It is important to point out that observation and analysis is performed concurrently, in that we do not have to wait until we have collected all the data before performing analysis.

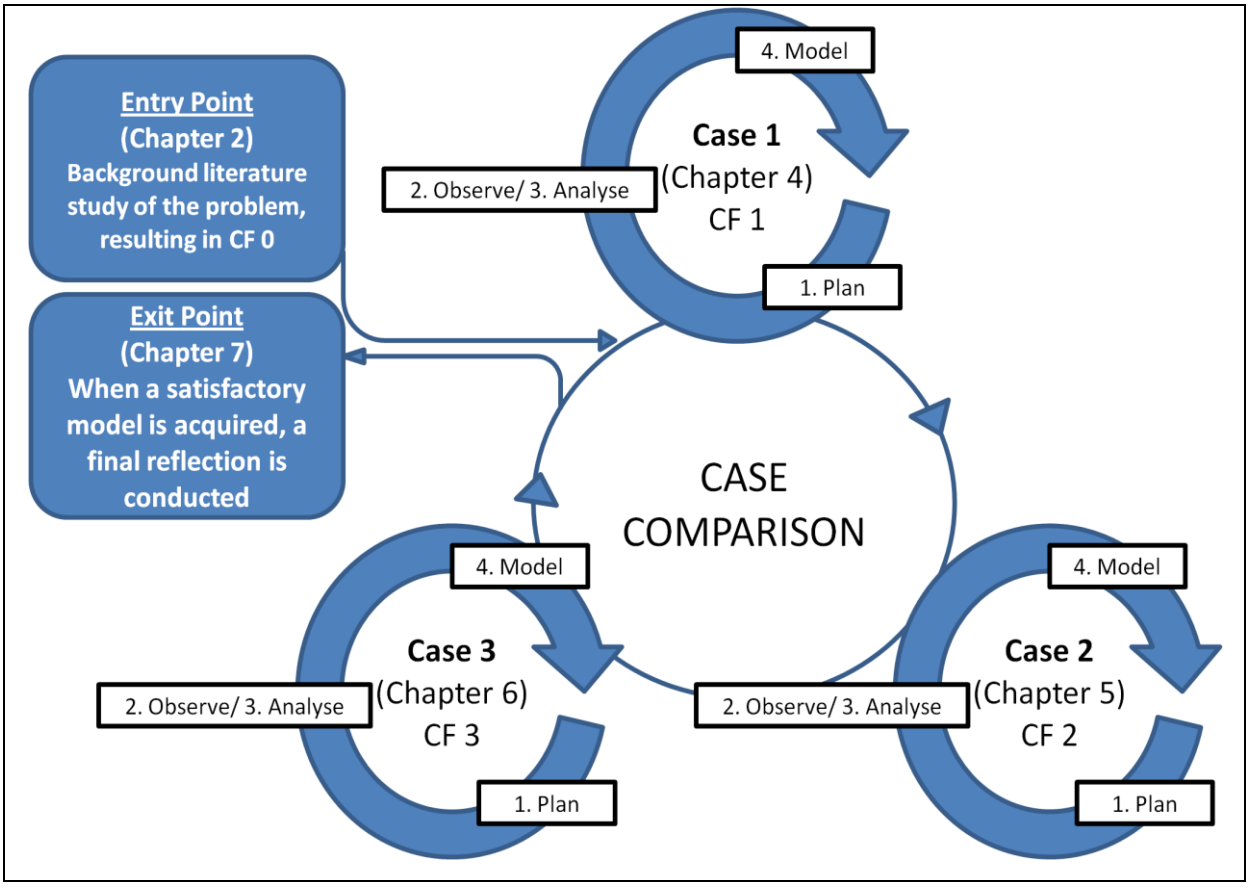


Figure 3-5: Thesis Research Plan

Three case studies were conducted, of research teams undertaking three interrelated projects, each over a period of months. These cases displayed creative teamwork that was embedded in the real world: they were not laboratory experiments, nor were they in any way simulated (such studies are rarely conducted in the IS domain, where teams' longer-term collaborations have been studied and described over a range of projects). Having connected studies to work with enabled us to describe team creative processes more meaningfully.

The three case studies — or cycles — conducted are as follows:

1. a team of researchers developed a strategic plan to determine their research scope and direction, the researchers based at the University of South Australia;
2. the core members from the first research team collaborated with international experts from partner universities — University of Hong Kong, China and University of Zurich, Switzerland — to develop a grant application to fund their research;
3. the research team having been funded by an organisation, in order to fulfil the requirements of their contract they generated for the funders a report of their research results.

We maintain that a snapshot of a single project is inadequate, as it represents only a small fraction of the team development dynamic. In the research domain researchers rarely develop a new research plan every year; thus we were fortunate to be in a position to describe for this thesis the creative process of a research team over a range of three cycles of study.

In similar fashion, categories and concepts emerging from any cycle could prove to be relevant to data from previous cycles. As we delved deeper into the understanding of Creative Teams, inevitably we formed new categories and concepts that we could not possibly have considered in the previous cycles. Equipped with these fresh insights, the 'old' data was reviewed, compared and again contrasted. This was not unlike Orlikowski (1993)'s situation, in which she compared CASE tool adoption experiences between two distinct organisations: she had to reconsider initial data from the first site after findings from the second provided her with new information. The cyclic nature of the bold circle in the middle of Figure 3-5 indicates that constant comparison between data, categories and concepts had to be conducted across diverse studies. As time passed, a concrete theory or model would emerge when there was no new knowledge to be gained: that is when we exited the research cycle (Exit Point in Figure 3-5).

Upon exiting the cycle, there was a final stage wherein we compiled the understanding obtained from all the cycles, as well as preparing an overview of the literature review performed at the initial stage and at the end of each cycle. We then discussed the understanding gained from the research, and the implications of the findings on Creative Teams and the IS domain in detail. In a way, the conceptual framework involves a series of evolving cycles that are constant over the duration of the research project (Carroll and Swatman 2000).

3.5 Empirical Analysis

3.5.1 Data Capture

Based on the general literature survey in Chapter 2, we have identified types of relevant data to be collected — namely, computer transactions as well as observational and interview data. Computer transactions include keystrokes, mouse movements, dynamic records of the development of all artefacts (e.g., specifications, plans, reports), file usage and sharing records, notes, asynchronous discussion records (online chat sessions, emails) and meeting records (minutes and agendas). The tools mentioned below will prove useful in capturing the required data.

"BSCW" (Basic Support for Collaborative Work) is a collaborative workspace package developed by Fraunhofer FIT and OrbiTeam Software GmbH. It is used by a team mostly for sharing project documents or artefacts. As each team-member makes changes to the artefacts, s/he is required to upload the newer version to BSCW. This allows another team-member to download the current version, and in turn, make his/her own contribution; thus changes in artefacts can be easily associated with a particular contributor. The time of each change can also be identified in relation to the overall timeline of the development of the artefacts. Further, BSCW contains discussion boards and calendars to capture asynchronous discussions.

3.5.1.1 Email Software

Members of a team can continue to communicate with one another between meetings and, in some cases, while any might be (temporarily) overseas. Asynchronous communication such as email is used to communicate between members of the research group. All email communication is retained, and can be examined to identify any supporting information that may indicate reasons for certain stages of the artefact to develop as they did.

3.5.1.2 Stills Cameras

Cameras are useful to capture images of artefacts at any stage, including non-textual artefacts such as physical models. They can also capture the scribbles left on papers or non-electronic whiteboards for future analysis.

3.5.1.3 Personal Diaries/Notebooks

These tools can be used to capture the thoughts of team-members when they are working on a project but not in the vicinity of technological apparatus.

3.5.1.4 Office Productivity Software

Potential records that can be collected: artefact file version log, artefact changes log (track changes), discussion log, email log, notes, artefact pictures (non-textual artefacts), and meeting minutes. 'Track Changes' is a useful feature of Microsoft Word that allows users to monitor changes in a document; it is especially useful for keeping track of changes and the person who initiated the changes.

3.5.2 Data Analysis and Modelling

In grounded theory, the data (observational records, interview transcripts and other documents) are often analysed using the constant comparative method described by Glaser and Strauss (1967) and Glaser (1992). In the initial step, also known as "open coding", we divided the data into 'incidents' and provide conceptual names. We then compared concepts and looked for patterns in them (similar concepts can be grouped together to form a category, whereas distinct concepts can be identified as properties of, and therefore fit into, a category). By constantly coding the data and comparing incidents with categories as well as incidents with properties of categories, we were able to build several levels of abstraction regarding the phenomena. Technically, a point of saturation will occur where there is no new knowledge to be gained, and a theory or model of the studied subject can then emerge from the data.

The previous paragraph described manual coding and concept discovery techniques; we were also able to use automated concept-mining software packages like Leximancer (Smith & Humphreys 2006) to assist us. Leximancer is a natural language tool that combines support for content analysis with automatic concept identification. It identifies concepts in large bodies of text by extending the principle of keyword search, detecting thesaurus-based concepts and seeding them throughout the text: the powerful set of Bayesian statistical analysis capacities that Leximancer possesses is, we believe, consistent with a grounded approach. So we were then able to group similar concepts to form higher levels of abstraction

until we achieved saturation point, where the model was considered complete. We then stored raw data, together with its several layers of abstractions, into a database schema or RES, wherein models were dynamically populated and updated.

3.5.3 Leximancer Introduction and Usage

Leximancer is a content analysis software that allows users to extract concepts and the relationships between these concepts from a text corpus. Davies et al. (2006) reveal other advantages that the software brings: e.g., objective analysis, the capability to identify both centrality and contextual similarity of concepts, and a visual representation of the concepts within a corpus. A white paper on the Leximancer.com Website claims the software is capable of quantifying relational information between concepts with ample flexibility to analyse natural language (Leximancer 2008); and the techniques employed by this software and its evaluation are discussed in a paper by Smith and Humphreys (2006). One of its major advantages over traditional methods is that it allows a user to consistently analyse large quantities of text in a short period of time.

Smith (2003) uses Leximancer to analyse the conference proceedings of the National Academy of Science from 1997 to 2002. With its assistance he identifies the key issues presented each year, and is thus able to analyse the development trend of concepts throughout.

A Leximancer analysis of Australian newspaper archives from 1998 to 2005 reveals a high occurrence of negative values such as sex, drugs, alcohol, violence and damage within the primary concept of Schoolies Week, an Australian tourism event involving students who have completed their final year of high school (Marzano & Scott 2006). The researchers point out that these negative press reports are at odds with brand values of the Australian Gold Coast, as projected by the Northern Territory Tourism Commission in the brand VeryGC.

In similar fashion, Leximancer is employed to extract and identify relationships between concepts in a medical database (Watson, Smith & Watter 2005); as well as used by Rooney (2005) to analyse knowledge policy documents, from which analysis results were utilised to demonstrate that the position taken by the World Summit on the Information Society (WSIS) on the topic of Knowledge is quite different from that of popular discourse.

Another study uses Leximancer to examine a total of 177 maritime accident reports between 1987 to 2001; from that investigation the researchers strengthen the argument that a major cause of accidents is the ‘lack of situation awareness’ by mariners (Grech, Horberry & Smith 2002).

3.6 Chapter Summary

In this chapter, we summarised the philosophical assumptions and approaches in IS research and the research methods often used in this discipline. We also discussed the philosophical stance adopted in this thesis and its research methods: the nature of our research is both qualitative and interpretive. We made use of key concepts from both grounded theory and structured-case methodologies to assist in the collection and interpretation of the data.

Chapter 4 describes the development of Conceptual Framework 1 (CF1).

4 The Dynamics of a Creative Team in a Strategic Planning Initiative

4.1 Introduction

In this section we report on a qualitative investigation of the processes followed by a Creative Team in action. The team studied was involved in a strategic planning exercise, very important to them because it set the over-all direction for a research project they were to undertake at a later stage. The discussion in this chapter is based on the qualitative analysis of data collected — recordings of signs of the activities of and process outcomes from the Creative Team while they performed this task. In overview, the interpretation shows that the strategic planning process was fairly opportunistic, with periods of build-up of content for the strategic plan, but also with periods of extensive review and re-conceptualisation of the problem domain.

We stated in the Chapter 2 that many collaborative information technologies are designed to impose a strict process structure within teams. There is a strong underlying assumption that teams undertake a process evolutionary in nature, and most support is provided to cater for this part of the process. In an evolutionary process, the output of the team grows more complex over time, as more content is identified and incorporated into the output object. However, researchers have identified that the evolutionary stage is not the only stage that occurs in team-based collaboration; for unstructured, opportunistic behaviour and processes are also existent. As shown in Wallas' model (Wallas 1926), ideas occur unexpectedly (or opportunistically) in the illumination stage. Similarly, the Catastrophe Cycle Model shows the revolutionary phase, where people involved in a project gather a new perspective on existing problems and remove unneeded content from the focal artefact.

We have also established that there is a dearth of technology available to support Creative Teams. The work of Nguyen, Swatman and others, analysed in Section 2.6, remains descriptive and indicative, and further investigation to strengthen (or, indeed, to shake) confidence in their results is required. Our observation of the Creative Team in this research cycle does provide further general support for these ideas.

However, in carrying out this study a new pattern in the complexity model was also identified, at a detailed level: in addition to the anticipated recurrent periods of evolution and reconceptualisation, we observed periods of consolidation. In this consolidation stage, the focal artefact document was lightly re-formatted through minor edits to its grammar and

sentence structure, and changes to the document appeared cosmetic in nature; and this activity appeared to reflect an underlying process of re-evaluation.

We also discovered that the processes undertaken by this Creative Team, although at an abstract level apparently structured and well-planned, did have episodes of less predictably opportunistic behaviour. Motivated by this observation, we attempted to strengthen our analysis through an intermediate literature review of process management techniques; and we presented that at the end of the chapter. Drawing on the software engineering literature, our focus was to characterise two extremes of an apparent continuum — the predictable approach and the flexible.

The findings of this study provide evidence that effective ICT support needs to adapt to the processes actually undertaken by formal teams. Effective management of a process that is poorly understood is not credible. The empirical observation founded on analysis, presented in this chapter, further addresses a gap in the literature — the lack of analysis of empirical evidence of creative teamwork from a 'situated' perspective — and provides further evidence of the need to aid the development of ICT-based support for team-based processes. The Conceptual Framework CF0 is revised and updated to CF1 at the end of the chapter; and CF1 forms the basis for the subsequent cycle of research reported in Chapter 5.

4.2 Conceptual Framework CF0

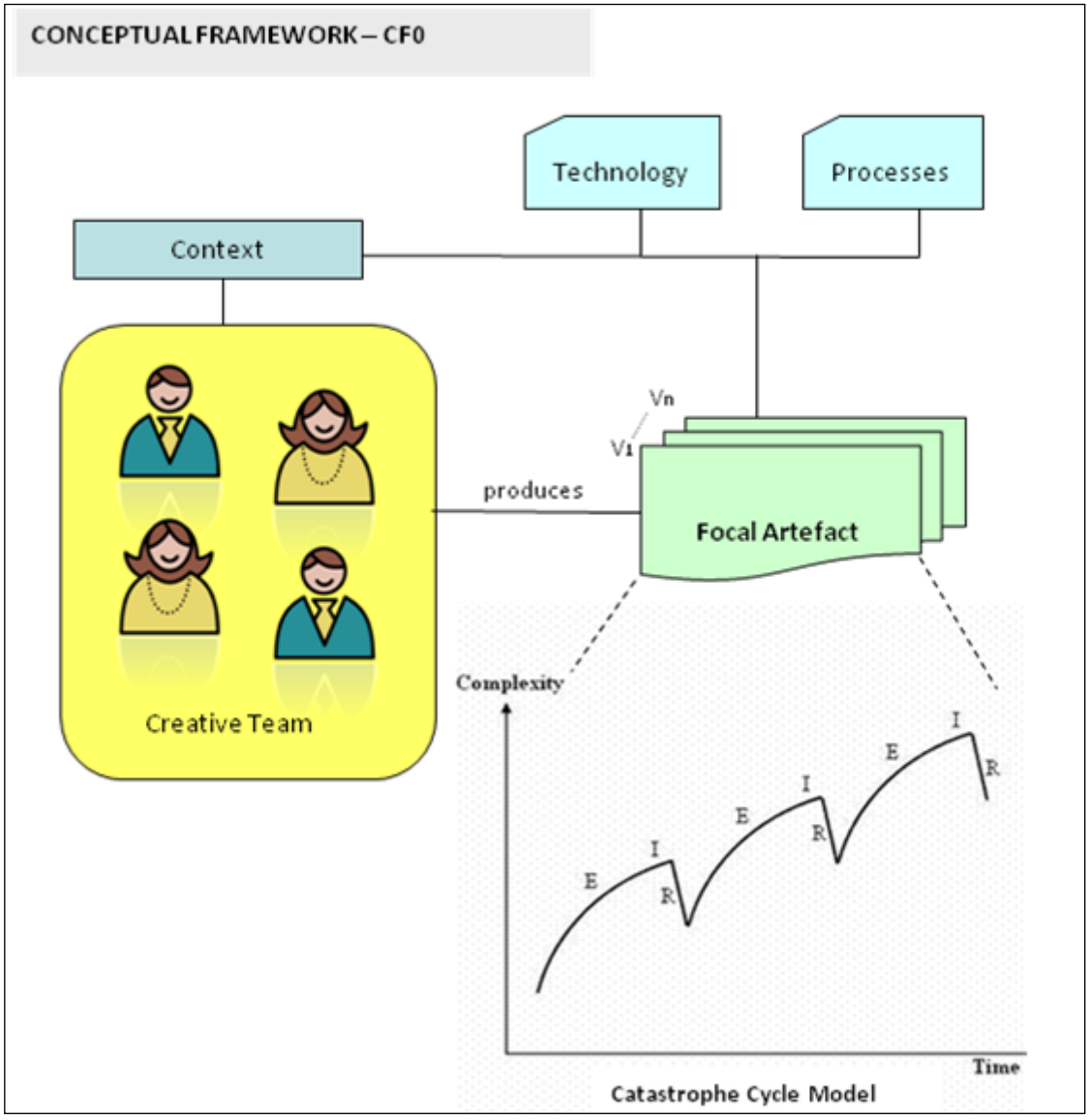


Figure 4-1: Conceptual Framework CF0

Figure 4-1 shows the Conceptual Framework CF0. Creative Teams (e.g., teams of managers, strategic planners, researchers, military command and control personnel) typically consist of four to eight members involved in a project. The team works continuously on an artefact and develops it from version 1 to version *n* over the course of the project. The final version of the artefact eventually becomes the principal output of that project.

Because the underlying process is inherently creative, the Creative Team 'makes' the freedom to choose a variety of processes and technologies to assist them while producing their output, the focal artefact. It appears important that their work should be unconstrained by the processes or technology that they have chosen to use.

The evolution of the artefact follows an interesting pattern. According to the creativity literature, humans do not follow a formal evolutionary path towards achieving a goal: they constantly face obstacles and opportunities for change, especially in work that is creative in nature. Following the arguments put forward by Nguyen et al. as they develop the Catastrophe Cycle Model that forms the basis of CF0, there is evidence of the evolutionary-revolutionary co-occurrence in typical requirements engineering work. This means that when performing their work, Creative Teams normally go through periods of incremental learning interspersed with periods of insight-driven re-conceptualisation.

Prior research underlying the Catastrophe Cycle Model interprets the creative process through the varying complexity of the focal artefact's being developed by the creative team (Nguyen et al. 2000). Although the archetypal Catastrophe Cycle Model has been constructed from empirical data, and additional empirical studies have been done which suggest that the interpretation of the Catastrophe Cycle is generally consistent with the retrospective interpretations of team-members, so far no research has been undertaken in which data are collected to allow the construction of a detailed model of artefact dynamics and process data collected to allow interpretation of the model to be conducted in the context of a contemporaneous record of the process.

Our first cycle of work, reported earlier in this chapter, was to conduct the first real-life, full, observational — i.e., activity-traced and focal-artefact-dynamic recorded — case study of a Creative Team at work in the context of the CCM. Being involved in the project had the advantage of allowing the carrying out of research into real work done by real people for professional purposes; for while studies in artificial environments may yield interesting results, their applicability to the real world is uncertain and for this reason their usefulness easily challenged. It was with this in mind that the research programme reported on was based on empirical studies in the real world.

With the data collected and subsequently analysed, we hoped to strengthen the conceptual framework, CF0, and also to find further insights to how a Creative Team functions. In particular, we sought to:

- generate a dynamic model of focal artefact development and thus increase confidence in the archetypal dynamic illustrated by the Catastrophe Cycle's being generally representative;

- present a detailed description of the changes of concepts in between artefact versions; and
- perform an in-depth interpretation of the model, through contemporaneous process records and by conducting pre, post and ad hoc, face-to-face interviews with team-members who participated in the project.

4.2.1 Planning and Preparation

Using CF0 as a starting point, we embarked on the case development stage where we first conducted a number of informal interview sessions with the project leader and the team. At this stage the composition of the Creative Team and the way the team functioned were explored. Fortunately, the Creative Team had adopted the habit of recording all formal synchronous meetings, keeping detailed minutes, and maintaining detailed communication records (including an email archive) and documents related to the project work; and that compilation of data was extracted for analysis. The data, although not entirely complete[2], was considered adequate the purposes of this study, and consisted of:

- 31 different versions of the artefact document in Microsoft 'Word' (or .doc) format; change-tracking was enabled throughout so that finer change dynamic data were also accessible.
- The timestamp and the person responsible for the creation of each version of the document.
- The retaining of all email communication throughout the period (the team's geographical dispersement made email one of the preferred communication methods during asynchronous collaboration).
- Meeting minutes and audio recordings of three group meetings held over the duration of this project.

The characteristics of the data will be elaborated on in the Data Collection subsection.

We were greatly interested to see that every time the focal artefact was updated, either by the removal or the addition of content, it was saved as a new version. This disciplined versioning provided us with the opportunity to scrutinise the dynamics of the development of the focal artefact, to be the ultimate output of the team. Using CF0 and the CCM as a starting point, a decision was made to first analyse the progression of the artefact over time, and then

[2] The researcher was advised by the University Ethics Committee that members of the public (and especially students) were often present in the general environment and shared offices, so privacy concerns meant that informal face-to-face meeting data and telephone conversations could not routinely be recorded.

to refer to contextual data, i.e., the communication records and meeting minutes, to explain that progression. Finally, we conducted further interviews with team-members, and the results of these interviews were used to strengthen our description of the artefact dynamics.

Referring back to CF0: previous researchers, when they developed the Catastrophe Cycle Model (Nguyen and Swatman 2000), had set a precedent on how to analyse the dynamics of the output of a team in reference to an indicator of artefact complexity. However, in earlier studies, the focal artefacts took the form of a requirements engineering specification; in essence they were pseudo-mathematical models. Nguyen et al. reduced the models to a digraph, then refined the digraph into one of the well-established graph complexity indicators. As was confirmed, the choice of complexity indicator is most important as a mechanism to convince any researcher. Absolute values of the candidate indicators are not important: what matters are their patterns of variation as the artefact develops. In practice, all indicators appear to change within the limits of tolerance useful in this kind of study: the focal artefact in this case, in contrast, took the form of an intrinsically unstructured free text document.

The final version of the focal artefact document itself was approximately 11 pages and contained 7000 words. Over time, the structure of the document changed: key concepts developed and changed, language used to describe ideas varied, and so on; so it was not clear how to identify a reliable complexity indicator.

Our key idea was unchanged from that of Nguyen et al.: we wanted to measure — in a non-semantic way so that the technique would be applicable to the entire class of textual documents — the content of each version of the artefact, and then to compare the amount of content, version by version.

A number of metrics was considered, including very simple variables like the number of words, sentences and/or paragraphs. An attempt was made to 'tokenise' each version of the document and later compare these tokenised versions. Finally, we settled on what we believed to be a method both persuasive[3] and relatively easy to generate: we used the automated content analysis software Leximancer to identify the key concepts in each version of the focal artefact, and the extent to which these concepts are interconnected in the document. The outputs from Leximancer were easily reduced to a digraph and then, following Nguyen et al.'s example, into a single variable for ready tracking.

[3] in that the reader can intuitively appreciate why any variable reflects the content of the artefact

In addition, it was possible to analyse and interpret over time variations in concepts contained within and inter-relationships between them. The process of measuring and coding the focal artefact, and the justification of the eventual choice of using Leximancer, is elaborated further in Section 4.5.

4.3 Case Description

We start by describing the case using the input obtained from the initial interviews.

The creative activity of the case studied was the construction of the initial strategic plan for the overall research project, the aim of which was to understand and support creative teamwork. This strategic plan was documented in the form of a position paper for publication in the Australian Workshop for Requirements Engineering 2005 (AWRE 2005). While the general direction of the research project was known prior to developing the strategic plan, the actual elucidation of the goal and the methods by which it was to be achieved remained poorly defined: so the nature of the project under study was that of a creative or ill-structured problem.

The strategic planning work observed (the subject of this study) occurred over a period of five months, carried out by a team of six people (three professional researchers and three postgraduate students) situated in a range of locations, which met face to face regularly (usually weekly) for both collaborative development and project management. There were, however, periods wherein members were dispersed over a variety of remote locations where the communication infrastructure was either primitive or unavailable; consequently, the audiovisual records of weekly meetings, while extensive, is not representative of all activities undertaken. Electronic communication such as the exchange of email and files was fully captured. Personal notes (e.g., of telephone conversations and/or informal discussions) were kept, but this aspect of the record is incomplete. Through the use of a collaborative workspace (www.bscw.de), the versioning of all files and the use of the change-tracking feature of Microsoft 'Word', a detailed model was constructed of the development of an artefact and the contributions of individuals within the team towards that development.

The focal artefact — the AWRE paper — was not actually modified during face to face team meetings, which focused on

- planning the construction of the focal artefact document,
- development of the research strategy concept and

- validation of the focal artefact against the evolving concept.

The focal artefact was created through asynchronous collaboration and, later, asynchronous review. Due to the predominantly asynchronous nature of the work, the audiovisual recordings do not reveal substantial detailed information about the development of the document: they do, however, reveal information about the issues concerning the team or concerning individual team-members during the project.

4.4 Data Collection

The nature of the data collected is described in detail in this section.

As mentioned, the data obtained comprised:

- 31 different versions of the artefact document (in .doc format),
- the timestamp and the person responsible for the creation of each version of the document,
- email communication records throughout this period (email was one of the preferred communication methods) and
- minutes of three group meetings held over the duration of this project.

The artefact document was stored in its various versions in the team's workspace. After an initial scan through these documents, we found that there was a repeat version that was entirely similar to its predecessor; and we found another irregular version in the collection in which there was a distinct lack of content. After interviewing the author, it was discovered that the version's presence was a mistake: the author had meant to upload a different document. Because there were irregularities in both versions, they were removed from consideration during the analysis of this case; so the final count was that of only 29 versions.

When a team-member uploaded to the workspace, the server would record the date the version was uploaded, as well as the name of the uploader and his comments or notes. Figure 4-2 illustrates further what the workspace server records looked like:

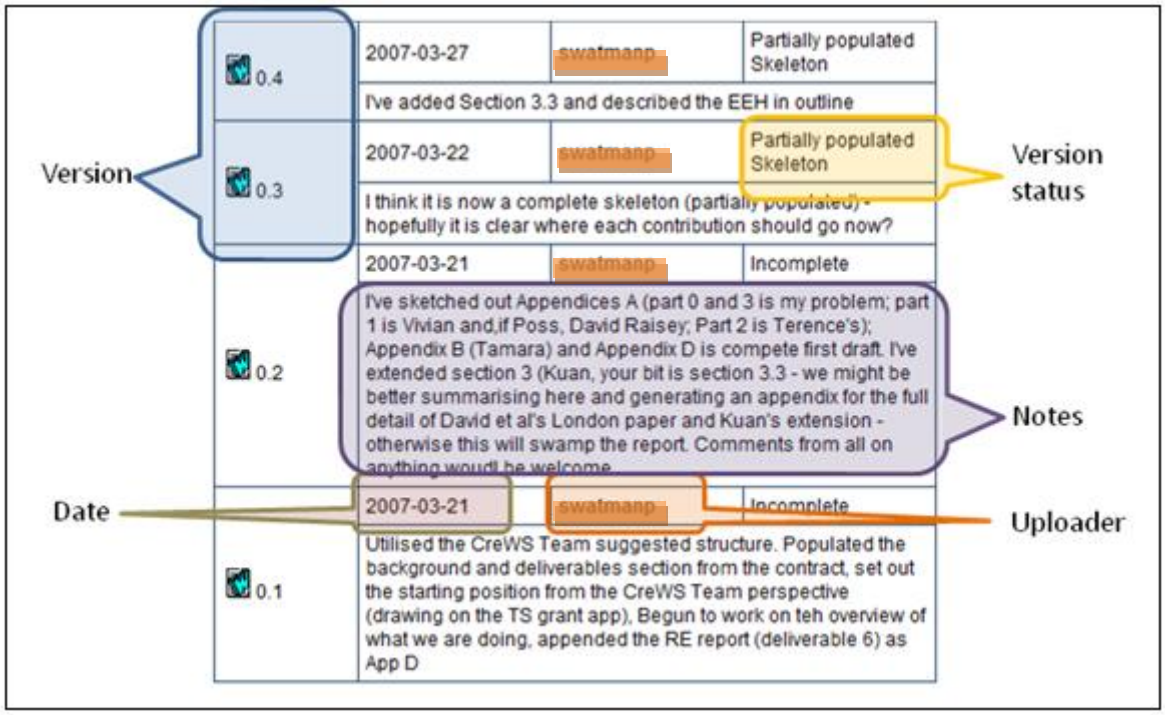


Figure 4-2: Excerpt of the data collected from the BSCW workspace server

Next, email communication records were obtained from each team-member — we retrieved both Sent and Received. Duplicate emails were eliminated, leaving us with a clean record of the events and responses that occurred over the project period. This record provided us with two advantages:

1. we could look for an explanation of what happened over the course of the project — why certain areas of the focal artefact were changed and the consequences of the change — and
2. the data helped us prepare for the subsequent interviews, providing a sufficient basis for seeking the motivation/s behind certain actions.

4.4.1 Conversation with the Team: a post hoc face-to-face exploration

Patton (1990) says that in order to discover additional facts that are not directly observable, a researcher has to make use of interview to determine what is in a person's mind and to complement existing data. Thus did we follow up on the findings from our direct mining of the traces (ad hoc records of artefact development) with a series of interviews of the participants in the project.

A face-to-face interview places the researcher in the inter-personal role of interviewer, through which s/he can receive valuable answers to the research hypothesis (Frankfort-

Nachmias & Nachmias 1996). Gathering data from interviews gives the researcher richer data, more flexibility and control than arise out of surveys, for example. We used an informal approach to interviewing, because we wanted more flexibility to probe the interviewees' feelings and their understanding of any given situation.

The core team-members involved in developing the focal artefact were interviewed, based on a set of questions:

1. Who made the changes to the focal artefact?
2. Was it a collaborative effort that led to the changes?
3. Why did you make the changes? — why at that time?
4. Do you think that the changes were important to the development of the project?
5. What did the changes mean to you?
6. What kind of abstraction could you derive from these changes?
7. How would you characterize the changes?

It is important to note that these questions served only as a guide; for the interviewees had to be allowed to explain the situation without there being too many constraints. If the conversation topic veered too much from the existing goals, we tried to steer it back to the set questions.

Q1 and Q2 rationale: we tried first to establish the background of the change that happened to the focal artefact at a particular point of time: because the upload of the document was performed by one person within the team, we wanted to find out if s/he was solely, if at all, responsible for changing the contents.

Q3 rationale: we attempted to probe to see if there was a pushing or pulling factor that motivated a person in performing the task; examples included submission deadline, pressure from team leader, etc.

Q4 - Q7 rationale: we tried to establish the value of a change from a team-member's perspective at a particular point of time: sometimes even minor changes to a document could amount to an important shift in project direction.

4.5 Data Analysis

The goal of this analysis was to convert the data we obtained into meaningful explanations of the processes and progress of the Creative Team. The primary data — the focal artefact collected — was in the form of a series of progressive versions of the document; therefore,

the way forward was to measure the content of each version and then make comparison between one version and another.

For any class of artefact there is no single optimal way of assessing the amount of content or complexity of that artefact, so several approaches were trialled. We first measured the number of words and the number of sentences in each version; but using these numbers as a measurement was not considered sufficient to reflect the complexity of each document. For example, a simple concept can be expressed in several ways: if the author wants to be concise, he can express the concept in a sentence; conversely, if he wants the reader to pay attention to a particular area of his work, he can express the concept repeatedly. In other words, one concept can take the form of one sentence or a number of sentences, depending on the author's judgement and the suitability of the situation.

We finally made a deliberate choice to use an automated content analysis software, Leximancer (Smith & Humphreys 2006), to help us discover the complexity of each version of the document. The reasons for using Leximancer were that:

- as an automated software package, Leximancer would provide us with an objective approach to constructing our model of changing complexity during the development of the focal artefact;
- the artefact was almost entirely textual, yet represented the development and association of a range of concepts, so a concept mining approach was viable.

4.5.1 Concept and Linkage Extraction

Leximancer combines support for content analysis with automatic concept identification. It identifies concepts in large bodies of text by extending the principle of keyword search through detecting thesaurus-based concepts and seeding them throughout the text. The powerful set of Bayesian statistical analysis capacities that Leximancer possesses is consistent with a grounded approach (Glaser & Strauss 1967) or an exploratory form of data analysis. Figure 4-3 on the next page shows the steps that have to be undertaken to gather the concepts of a document.

Firstly, the set of 29 versions was combined together, then preprocessed to remove change-tracking from the document so as not to corrupt the existing data. Next, singular and plural concepts were merged in the thesaurus — e.g., ‘team’ and ‘teams’, as they are essentially the same concept.

Leximancer was then asked to identify a minimum of 140 concepts from within the total document. The number of concepts is arbitrary: we set the number at 50, and then again at 140 when seeking confirmation, and observed how they compared with each other. Leximancer was then asked to analyse this set of documents in one run; this meant we were asking it to learn and identify the concepts that existed in the entire 29 versions of the document. After this analysis, the result took the form of a universal concept set[4]; once we obtained this set, we ran each version using that universal set as a baseline to obtain the version concept set of each version.

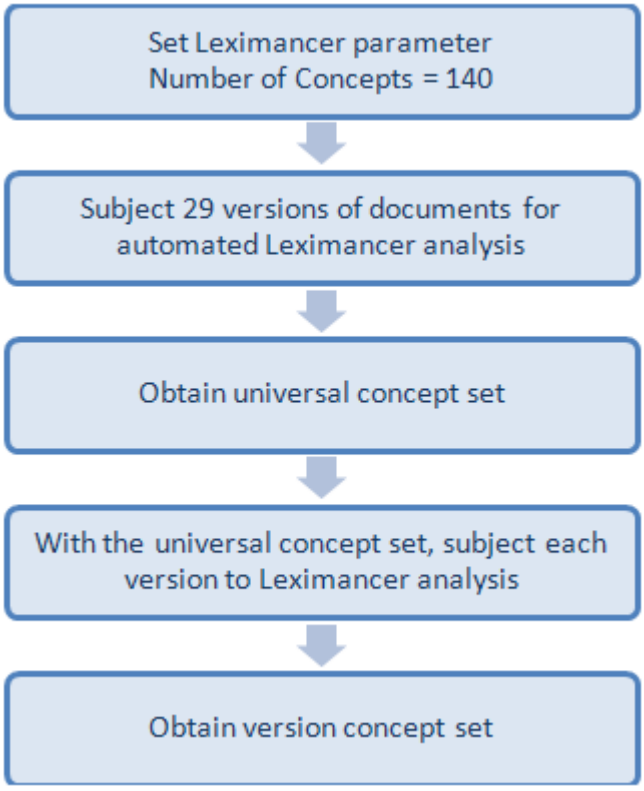


Figure 4-3: Concept set extraction for one focal artefact version

An example of the concept set obtained in each version is shown in Figure 4-4 on the next page: it is an excerpt of the concept set of version 1 of the focal artefact. For explanation purposes, we focus on the concept 'information': the number 9, highlighted in blue below that heading in the diagram, shows that there are 9 occurrences of the concept 'information' in version 1. The number 4 is highlighted in orange to show that the concept 'information' and the concept 'services' co-occur 4 times in the document. Similarly, it can be seen that the concept 'information' and the concept 'workspace' co-occur 6 times.

[4] A concept set contains the number of concepts (modeled as nodes), as well as the number of linkages (modeled as edges) between those concepts.

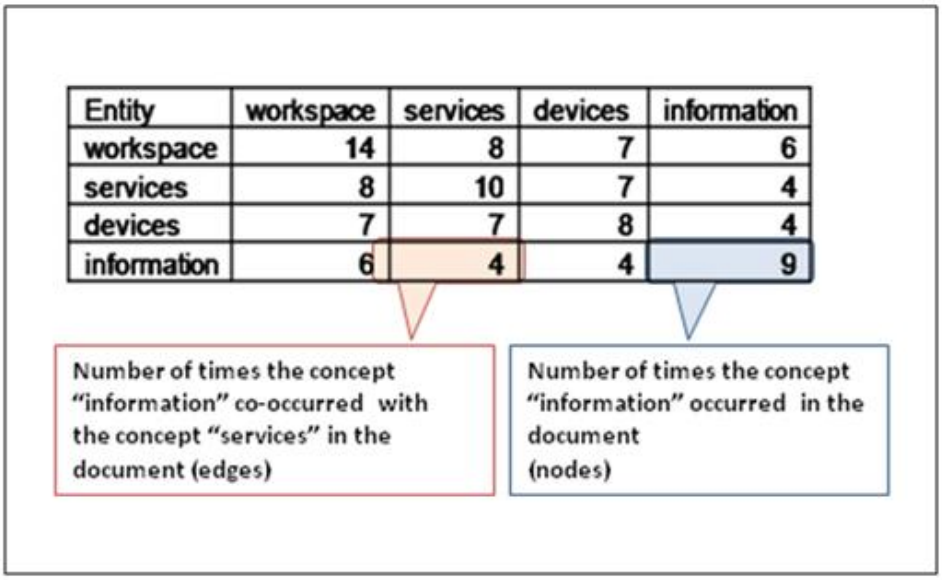


Figure 4-4: An excerpt from a Leximancer-produced concept set matrix

It is important to note that many other concepts in that focal artefact version are not shown here due to space constraints. This diagram serves only to explain how we performed the analysis.

Leximancer creates a two-dimensional matrix labelled along each axis with the names of all concepts found. The main diagonal contains the number of occurrences of each concept within the text corpus, while the remaining cells of the matrix contain the number of pair-wise co-occurrences of concepts. This data can be represented as a multiply-connected graph (each unique concept represents a node, each pair-wise concept co-occurrence represents an edge). With this matrix, a single value representing the complexity of the graph can then be calculated.

After exploring all alternatives, we found the conventional graph-theoretic approach suitable for our analysis. Thus is the complexity measure of a version defined:

$$Complexity = Ew + N$$

where N represents the number of unique concepts (as nodes), E represents the concepts that co-occur (as edges) and w is the number of times they co-occur.

With this equation, we could calculate the complexity value of each version of the document. These values were then compiled and graphed to provide a picture of the dynamics of complexity change over time.

We mentioned earlier that we had asked Leximancer to identify 140 concepts: it was for the purposes of obtaining further confirmation solidifying our approach that we repeated the entire process by setting the parameter "number of concepts to be identified" at 50; and the results obtained will be shown in the results section in this chapter.

In summary, our approach was to:

1. fix the total concepts to be found in the focal artefact at 140;
2. subject the entire corpus of 29 versions of the focal artefact to automatic Leximancer analysis;
3. instruct Leximancer to store the concept matrix for each version;
4. for each version, calculate the complexity measure, Ew + N, where N represents the number of unique concepts (as nodes), E represents the concepts that co-occur (as edges) and w is the number of times they co-occur;
5. repeat steps 2-5 for the total number of concepts of 50; and
6. construct a development model in the form of a normalised complexity graph for these different versions of the focal artefact.

4.5.2 Delta Computation and Visual Inspection

What we obtained from that method was a complexity graph; and there was a need to populate the model further. To do that, we conducted an in-depth exploration of what occurred from version to version — in other words, the version-by-version dynamics of the artefact. The methods used were:

1. to compute the differences of concepts and their links between two versions, the results being represented in a delta table;
2. to obtain contextual information such as the authors/creators and the date when the version was created;
3. to conduct a visual inspection of the artefact and its previous version, during which we examined all the versions of the document to gain an overview of the changes; carried out open coding to record the changes as they occurred in each version; used coding to identify changes in sentences, paragraphs or sections as well as to structure changes through identifying the evolution of sections and headings — during which activity it became evident that the initial codes used were insufficient to identify subtle

distinctions between related data elements, so the coding approach was expanded to allow for further distinction between related data items — and

4. to compile and present information from steps 1-3.

4.5.3 Results

It is evident that at a high level of abstraction the Catastrophe Cycle's general pattern is suggested (Figure 4-5). While the graph followed the CCM with adjustments to allow for the ever-decreasing height of the peak, it also incorporated a phase in each cycle not represented in the original model. It was evident from the chart that after each rise and fall in complexity a short period of relative stability followed, which appeared to occur when the chart reached a point at which the current complexity measure was lower than or approximately equal to the point that preceded the peak. It is also important to note that there were no significant differences in shape between graphs, whether Leximancer's "number of concepts to be identified" parameter was set at 50 or at 140.

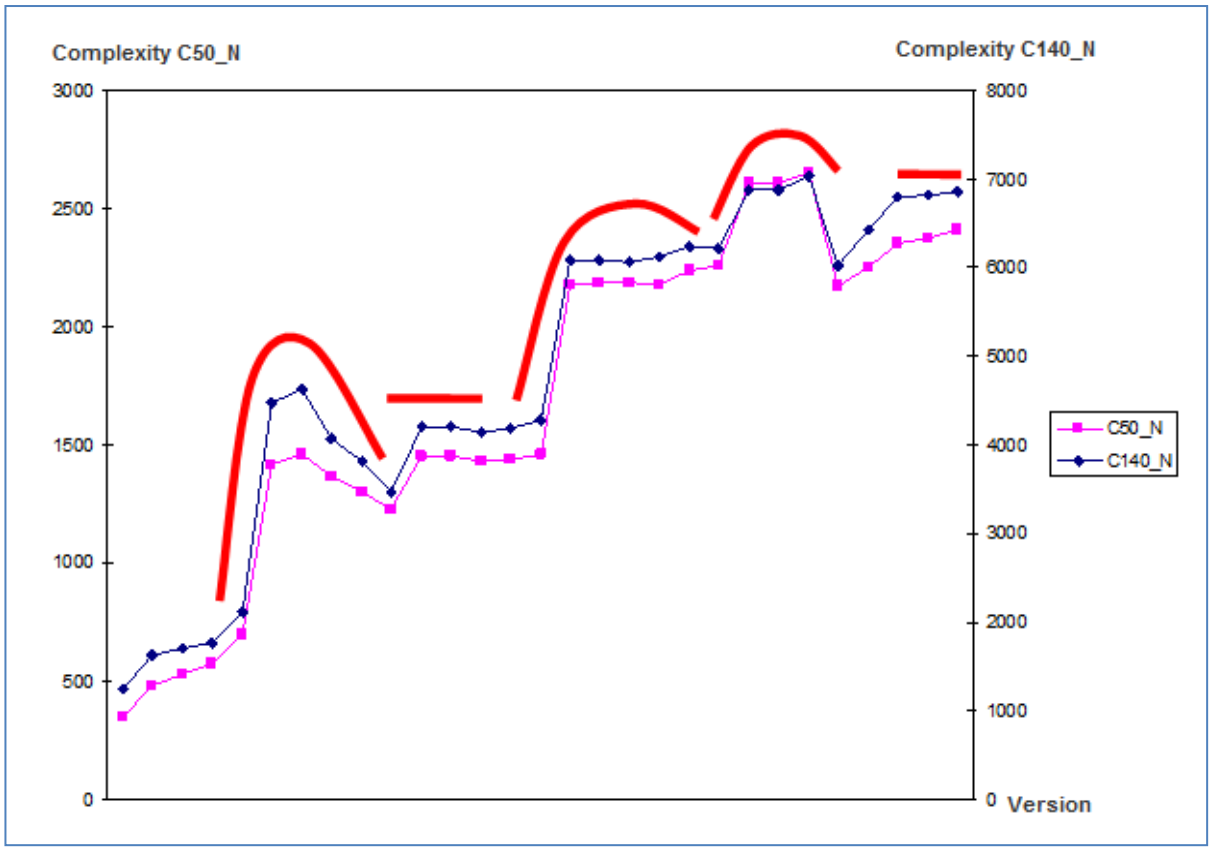
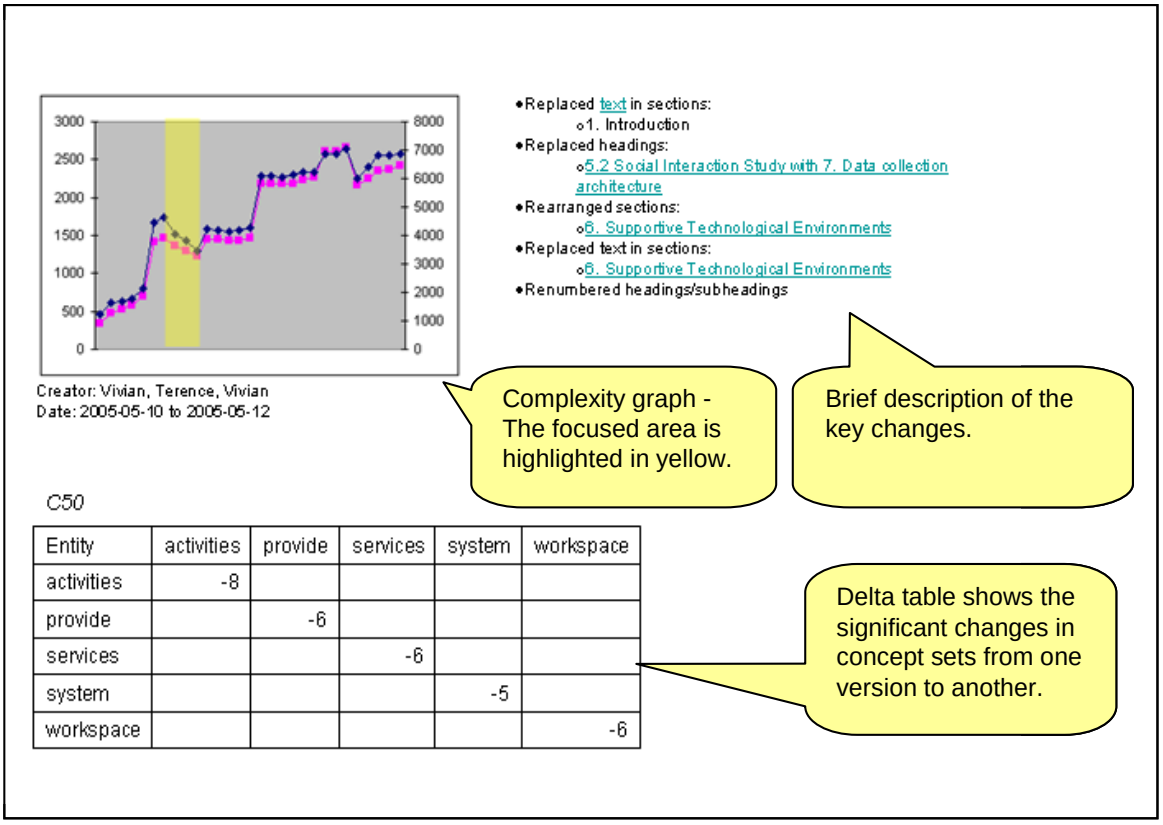


Figure 4-5: Artefact Dynamics Model - Overall



Entity	activities	provide	services	system	workspace
activities	-8				
provide		-6			
services			-6		
system				-5	
workspace					-6

Figure 4-6: Artefact Dynamics Model - Single Version

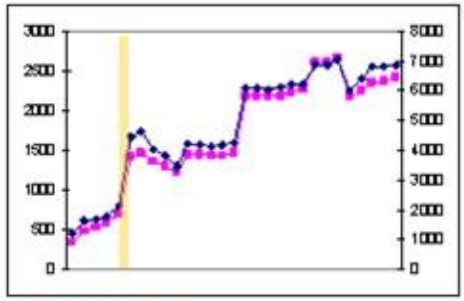
Figure 4-6 shows an example of the in-depth information that we compiled: in this figure the dynamics from v7 to v11 of the artefact document are shown. The top left portion of the diagram shows a miniaturised complexity graph where the area of interest is highlighted in yellow. The creators of these versions and the creation dates are listed directly below the graph. The top right section of the diagram shows the key changes that were detected through visual inspection of the artefact. Finally, the delta table on the bottom section of the Figure shows the significant concepts that have changed.

4.5.4 Process description

We then considered the development of the document in more detail. We interviewed each participant about the actions they took in each version of the focal artefact; and it is to be noted that one version (v10) was removed from analysis because it was incomplete (having been mistakenly uploaded by one of the team-members).

From v1 to v5 entire sections were added to the document through collaborative work between participants 2 and 1, while the project leader co-ordinated and made email comments when necessary. Participant 3 contributed new ideas to the paper in v6 and refined those

ideas in v7. Figure 4-7 below shows the events that occurred during v6 — e.g., the addition of sections, comments, diagrams, etc.



Creator: T & P
Date: 2005-05-09

Difference between v5 and v6

- Added title
- Reformatted text
- Added sections:
  - Abstract
  - Introduction
  - A Catastrophe-Cycle Model of Learning and Design
- Added comments:
  - Introduction > "Comment [P1]: References"
  - A Catastrophe-Cycle Model of Learning and Design > "Comment [P]: Reference"
  - A Catastrophe-Cycle Model of Learning and Design > "Comment [P]: Reference"
- Added text in sections:
  - Orchestration Development
- Added diagrams:
  - Table I. Some of the cognitive activities in intense collaboration
- Added references

Entity	activities	approach	cognitive	information	method	process	requirements	research	support	teams	time	work	workspace
activities	12		5	6		7							
approach		5				5							
cognitive	5		6										
information	6			6									
method					5								
process	7	5				12	5		7	5			
requirements						5	5						
research								6					
support						7			9				
teams						5				5			
time											5		
work												7	
workspace													5

Figure 4-7: Artefact Dynamics – v5 to v6

In v8, the team realised that the paper was slightly off-focus, containing material that was related to but did not support the primary purpose of the paper; as a result, substantial blocks of content were removed and the remaining text streamlined.

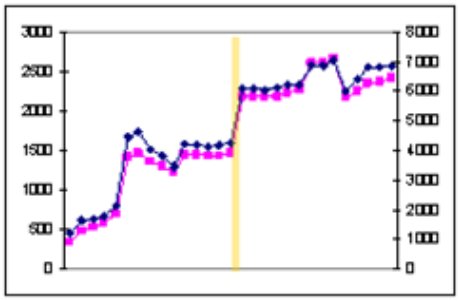
Removal of content occurred in v8, v9 and v11, contributing to a sharp decline in complexity (see Figure 4-6 on previous page).

In v9 and v11, further text was removed to make the document more understandable to the reader and also because of constraints on the number of words allowed in the paper. Three

diagrams were consolidated and combined into an overall diagram, leading to a reduction in perceived complexity.

An increase in content occurred again at v12, and a new diagram was added to provide visual support. The team leader added new content and comments to the paper, requesting further responses from all participants.

From v13 to v16 the number of concepts remained relatively stable: modifications were focused on the re-numbering of sections, the removal of unnecessary headings and the re-arrangement of sections of text. Comments were added to communicate the direction of the document to other participants. In addition, placeholders were included so that participants could contribute additional sections at a later time, and minor corrections were made to grammar and writing style.



Creator: T
Date: 2005-06-04

Difference between v16 and v17

- Reformatted text style
- Removed sections:
  - 3.3 Situation Interpretation
- Replaced headings:
  - Figure 2. Architecture with Figure 2. Architecture of RES
- Added text in sections:
  - 3.1.3. Technology-mediated interactions
  - 3.2. Situation Modelling and Interpretation
  - References
- Added comments:
  - //D stuff here
  - //V: describe what interactions captured (refer to section…) //D has mentioned that orchestration can make the turtles hump faster or slower…
- Added diagrams:
  - Table 1. Different representations of Activity Theory components
  - Figure 3. Nexus between cognition as represented in the human mind and the raw data, which represents pieces of cognition, gathered from the workplace...
- Added sections
  - 4.3. Orchestration Interventions
- Added headings:
  - 4. Catastrophy cycle model section
- 4.1 Social
  - 4.2 Technological
  - 4.3 the effects of orchestration in the context of the cycle model
- Rearranged sections:
  - 4. Orchestration Development
- Renumbered headings
- Added reference links

Figure 4-8: Artefact Dynamics - v16 to v17

In v17, participants 2 and 3 added a large amount of content in response to the request of the project leader at v16; amongst the major additions were sections of text and diagrams, and details of the altered content are shown in Figure 4-8. However, the participants commented that it might need to be condensed at a later date, possibly after receiving further comment from the team leader.

From v18 to v22, minor spelling and grammatical corrections were made. Complexity increased again between v23 and v25: in v23, participant 1 contributed his ideas in the form of text and a diagram, in response to the project leader's comment from v16 (Figure 4-9).

Minor refinements to the writing style were made in v25, with requests for further contributions made by the project leader.

Overall document content was again reduced in v27: participants 3 and 2 removed a section as well as some other text, for they felt it necessary to remove unnecessary information that did not contribute to the reader's understanding, thus also reducing the number of words in the paper. Comments inserted by participants were also removed from the document.

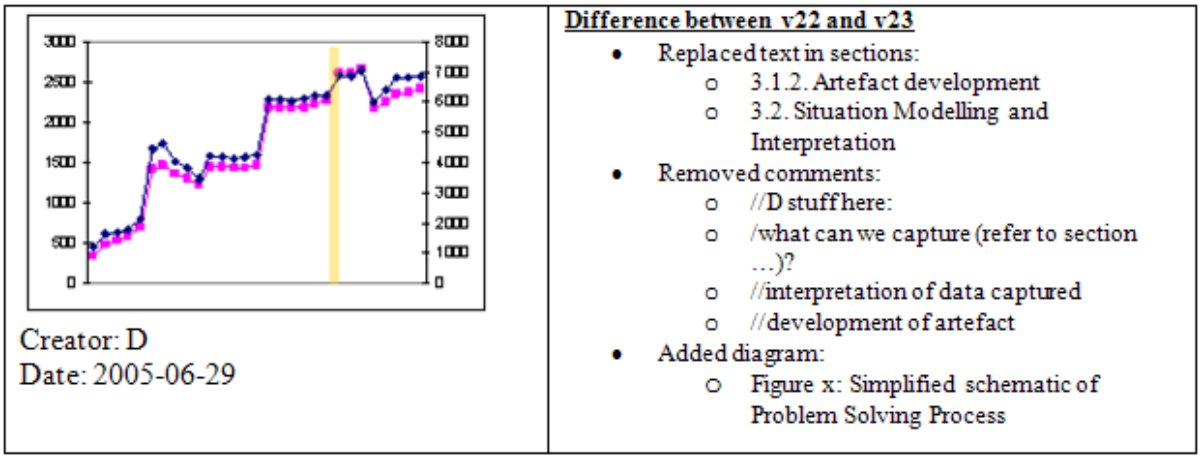


Figure 4-9: Artefact Dynamics – v22 to v23

4.5.5 Discussion

Summarising, Figure 4-10 shows the primary changes that occurred during the development of the document.

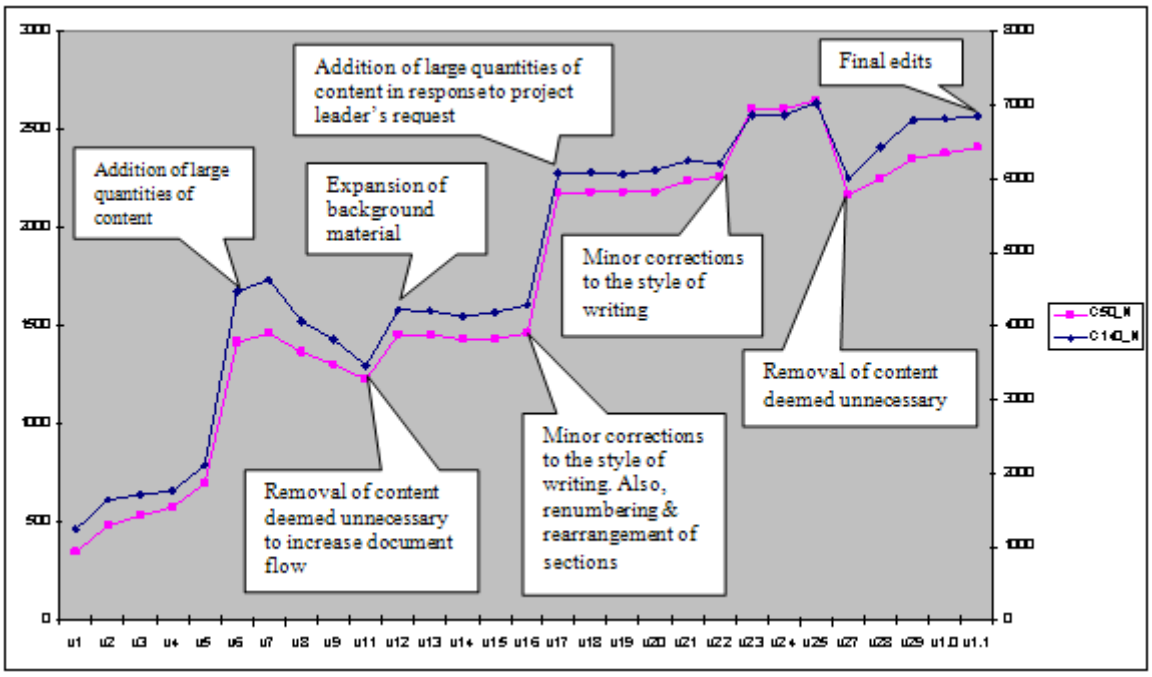


Figure 4-10: Complexity Measure with Notations

We can postulate elaboration of the Catastrophe Cycle for future research, based on our case, thus:

- periods of addition followed by periods of removal of content occurring frequently during artefact development;
- infrequent periods when only minor variations occur in the document so that it does not undergo significant structural change; and
- a period of review and reassessment beginning each period of evolutionary development other than the initial one.

With regard to the last point, it is unclear whether such a review period is to be associated with the development of all artefacts or whether this is peculiar to text-intensive documents (though we have no reason to believe this to be the case). However, this phenomenon will be explored further in our mini literature review at the end of this chapter, and subsequent cycles of investigation in Chapters 5 and 6.

What is evident from the analysis is that while the team applied a process that was superficially systematic, there were clear opportunistic episodes and external stimuli which,

even at a coarse granular level, clearly disturbed what might otherwise have been a systematic process. Drilling deeper into data/interviews, we can see that the process seemed normal to the participants, which suggests that while this group was opportunistic and flexible, there was a clear management control of the whole process through which the progress, duration and results were being monitored.

The team resolved tensions dynamically, undertaking a process that was predictable and that perpetuated for its duration the need for opportunistic insight/external stimuli behaviour. This provides evidence that effective ICT support needs to adapt to processes undertaken by formal teams; in our view, it is not possible for a team to function in a fully heuristic manner. The way forward for collaborative teams might be for them not only to conform to professionally-driven heuristic approaches, but to also have support from a contingency 'toolkit' of various sets of tools, allowing them to respond appropriately to different types of situations in a dynamic project environment. This situation is occurring currently in the software engineering domain.

4.5.6 Key Observations

While performing the data analysis, two important observations have emerged:

1. During the process of data collection and analysis we found that although there were inherent process controls within the Creative Team, the team did indeed have opportunistic moments of rethinking their problem domain; so the process they follow is one somewhere between being severely controlled and predictable to being very flexible.
2. In addition to the evolutionary and revolutionary phases of a creative process, there is a consolidation phase in which the focal artefact is reviewed/reassessed.

According to the structured-case methodology that underpins this thesis, a literature review should be performed at the end of each cycle of research, the purpose being to support the findings from the data analysis. We will use this cycle literature review to explore current management processes as well as to provide the review phase of an authoring process.

4.6 Cycle Literature Review: Management Processes

The literature indicates that there are basically two, contrasting approaches to managing teams, both widely accepted:

1. a formal, systematic approach of continuous process-monitoring and refinement;
2. a flexible and responsive way of dealing with changing environment client requirements.

Drawing on an example in the software engineering domain, the two distinct approaches to have achieved currency in the literature are the Capability Maturity Model (CMM) (see, e.g., http://www.sei.cmu.edu/cmmi) and the agile management method (Cockburn & Highsmith 2001; Highsmith & Cockburn 2001): CMM-style management might be said to be focused on control while agile management focuses on flexibility.

The importance of predictability (cost/delivery dates) and confidence in the quality of the product of the software engineering process are clear. The dominance of organisations' descriptions of their own SE process management in CMM-like terms is, therefore, unsurprising: indeed, in the defence sector, such an approach is often mandated by clients. Despite CMM's successes in certain situations, critics have argued that it puts priority on the processes within an organisation rather than on the people (Bach 1994), and covers only a small amount of the good practices in a software development environment (Bamberger 1997).

It is also clear, therefore, that an agile approach to process management can require the client (e.g., software engineering management) to cede an uncomfortable, perhaps even unacceptable, level of control in return for the process flexibility and creativity it promises: in other words, it is perceived by many organisations that the agile processes are ill-defined. Some researchers argue that there are no standard guidelines, and that people who follow the agile approach may find a lack of discipline for the carrying out of their tasks (Rakitin 2001; Paulk 2002).

Interestingly, a review of the academic literature reveals that while there is a strongly supportive polemic, there is a surprisingly sparse formally-situated empirical basis in real-world professional practice to support the claims of effectiveness of either of these approaches to process management; and as far as we have been able to ascertain, no situated empirical basis in respect of geographically-distributed software engineering.

State-of-the-art project management approaches to high-quality software engineering restrict what appears to be necessary flexibility within the process by imposing apparent conformity to overly-rigid systematic process models. We say “appears to be necessary” flexibility and “apparent” conformity because our foundational research (to come) strongly suggested that in practice the paper trail does not properly reflect the software engineering process that has occurred — a process that, while conforming to a professionally-derived heuristic, is characterised by opportunism and insight.

The best software engineering organisations have become relatively adept at managing local teams while maintaining a balance between predictability and flexibility. As both remote and distributed software engineering becomes more significant, however, we need to understand how to build and implement software engineering process models that resolve the tension between a need to control quality effectively and a desire to foster creativity and effectiveness through an appropriate level of agility and flexibility.

There has recently been a number of calls for moderation between the two extremes of process management approaches (CMM and agile methods) (Boehm 2002; Paulk 2002; Harris, Hevner & Collins 2006; Turner 2007). In practice, the best software engineering organisations have become relatively adept at semi-formally managing local teams while maintaining a balance between predictability and flexibility.

4.7 Consolidation Phase

There is a body of seminal research work focused around Flower and Hayes (1981)’s work on writing. They have produced a model of the writing process, representing it as containing several recurrent stages — for instance, planning, drafting and reviewing. The creation of ideas, their organisation and the goal-setting occurs during the planning phase. Drafting involves the translation of the author's thinking into text, or the actual action of producing the words that comprise the document.

Of particular interest to us, however, is the reviewing stage. This stage contains two sub-stages: evaluating and revising (Flower & Hayes 1981). The authors state that the reviewing period involves processes of authors reading what they have written and evaluating/revising their text. They go on to say that this reviewing sub-process can actually interrupt any other process during the writing: it creates intermittent gaps in with the work. Another researcher, Kellogg (1987), points out that reviewing text includes

> … reading text and detecting errors or problems either in the text or in the plans for text (Kellogg 1987).

Following this, Bangert-Drowns (1993) states that there are lower-level processes in the authoring of a document; changes to the text can be simple editing like revision of grammar and spelling or rearrangement of text.

Referring back to the first cycle of study in this thesis, we mentioned a number of reviewing periods wherein the authors did minor revisions to their ideas by changing the grammar, spelling or sentence structure of the document.

4.8 Conceptual Framework CF1

Using both the analysed data and the subsequent literature review, we have upgraded the conceptual framework to CF1, as shown in Figure 4-11: the management processes, showing two extremes, are displayed on the top right corner of the framework.

As well, the Catastrophe Cycle Model was updated to contain a consolidation phase.

The conceptual framework (CF1) forms the basis for the two subsequent cycles of studies that will be described in Chapters 5 and 6.

We mentioned earlier that there is little situated empirical evidence to support the building of CITs for supporting management processes; it is not plausible that there be effective management of a process that is poorly understood. So this chapter has the potential to contribute to existing literature because it contains results of empirical observations of an actual, professional team. In doing so, we are a step further in fulfilling thesis objective O1. We have also addressed O2 by examining the progress of a team by monitoring the focal artefact dynamics. Further, we extended the Catastrophe Cycle Model to a project document development – this provided us with an initial platform to explore future intervention strategies (O3). However, we will leave the discussion of these strategies for the moment, as we explore more evidence in the subsequent chapters – chapters 4 and 5.

In conclusion, we have become concerned that most research (especially R&D) aiming to develop support for collaborating teams as they undertake ill-structured or creative work is all too often based on an assumed and possibly inappropriate model of the character of the process that needs to be supported: this chapter also offers and illustrates a strategy for the observation and modelling of team behaviour and opportunistic process selection within a professional heuristic framework.

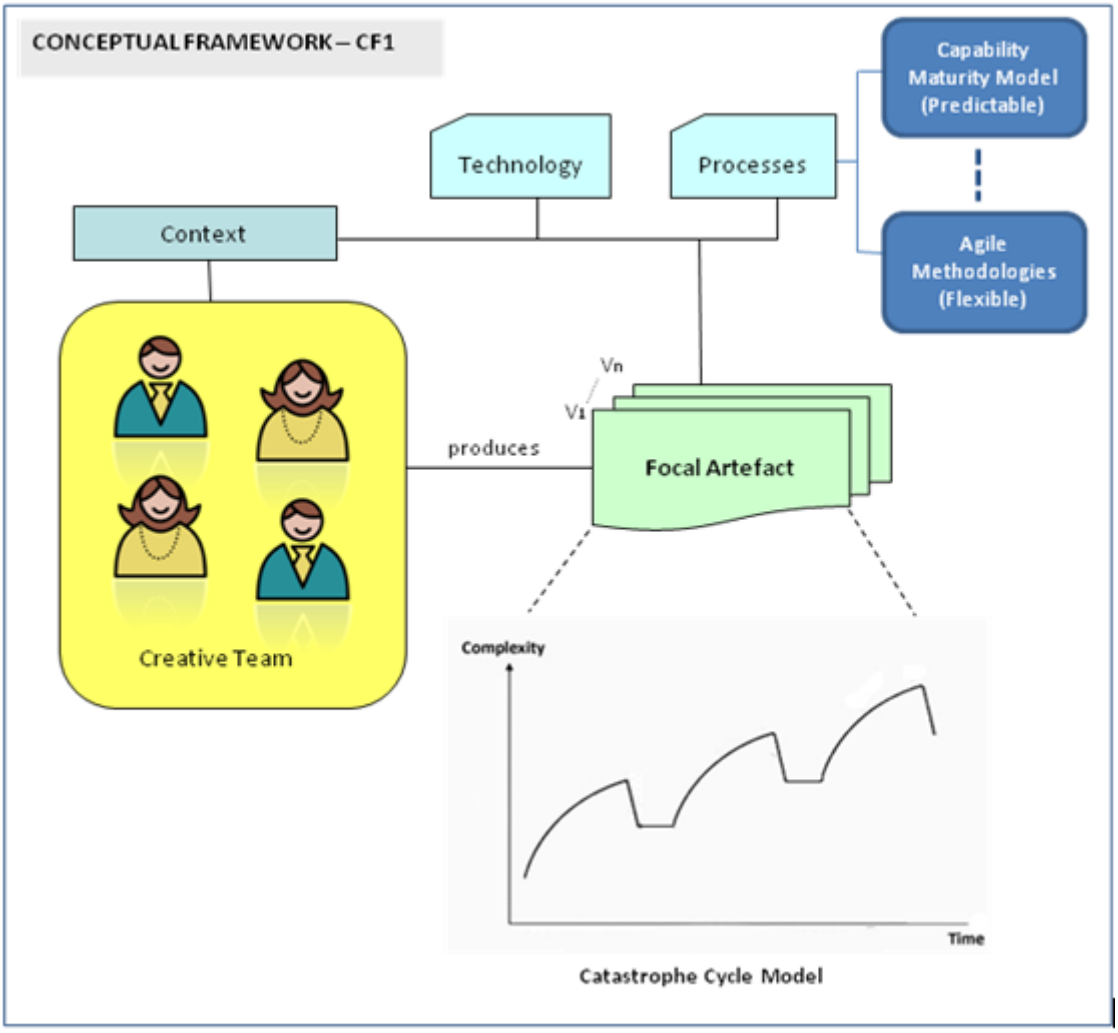


Figure 4-11: Conceptual Framework, CF1

5 Creative Team Dynamics: Funding Application

5.1 Introduction

Understanding team-based creativity is essential for the Information Systems community. Based on the extensive studies into Collaborative Information Technologies, researchers have identified a real world need for CIT-based support for collaborative teamwork but a lack of understanding of its nature, leading to insufficient diffusion of research outcomes into practice. This chapter seeks to enhance understanding through an observational study of a team working on a follow-up problem. Using a method similar to that described in Chapter 4, we analyse the communication record within the team, collect perception data through post hoc interviews and use them to explain the directly modelled evolutionary path of the focal artefact. Finally, we contrast this study with a model of the initial problem-solving process. We show a similarity between exploratory and exploitative creative work processes and demonstrate that expert teams work in non-linear fashion, heuristically guided but unpredictable at a detailed level.

To briefly recap, the IS community has long acknowledged that in many aspects of its domain an understanding of team-based creativity is essential. In Computer Supported Cooperative Work, for example, research in creative problem-solving is central to informing tool design and the provision of ICT-based support for teams (Neale, Carroll & Rosson 2004; Crabtree, Rodden & Benford 2005). In Group Decision Support Systems much work has been dedicated to improving the decision-making process — a key element of creativity — by developing tools to support the cycle of brainstorming–evaluating–voting–prioritising ideas (Fjermestad 2004; Arnott & Pervan 2005; Rains 2005). Further, in process mining researchers have designed tools to analyse ad hoc unstructured processes within teams, with the hope of eventually providing support for them through the relevant technology (van Dongen & van der Aalst 2004; Dustdar, Hoffmann & van der Aalst 2005).

However, there is still much need for research in this area. Two extensive studies have recently been carried out on the nature research into and impact on real world organisations of CITs — which term is used throughout this thesis to encompass all forms of technology that enhance collaboration within organisations and groups (Shumarova & Swatman 2008b). Shumarova and Swatman (2008a) found little evidence of the impact of formal CITs on organisations: in fact, other than email, shared calendars and shared filesystems (in fact, MS

Exchange, Lotus Notes and Sharepoint/Intranets) few formal CITs were found to have been absorbed into organisations, and those are disappearing.

Shumarova and Swatman (2008b) also found, however, that there is increasing organisational impact from "Shadow CITs" (after Raden (2005)'s definition: a set of IT tools "used for performing IT functions but not part of the mainstream IT organisation"), such as blogs, wikis, Facebook and/or Twitter, some of which have been formally absorbed by some organisations following earlier but informal diffusion within them. This result suggests that there is a real world need for support from CITs, but that most existing formal CITs either do not address relevant problems or do not address them in culturally appropriate or effective ways (Shumarova & Swatman 2008b). This further suggests that the underlying nature of collaborative teamwork is not sufficiently understood to enable it to form an appropriate foundation for the development of CITs that can transition from research to practice.

This research reports results from a programme of research into CITs that focused on understanding the nature of the processes that underpin what we term "creative teamwork" — the kind of teamwork which, while guided by professional heuristics, is resistant to pre-definition. We further discuss our earlier research, which suggested that much professional teamwork (software engineering, strategic planning, research, etc.) falls into this category. Since the diffusion of formal CITs has been so limited, we are concerned that the models of team behaviour that underpin the design of formal CITs may be misleading. Consequently, our overall research design is abductive, based on real-world empirical observations and informed by critical reflection on established theories.

This research was founded on a series of studies of creative processes in requirements engineering teams (Nguyen, Swatman & Shanks 1999; Nguyen & Swatman 2003), which develop a model of the requirements engineering process as inherently creative — naturally comprising periods of incremental learning interrupted by periods of opportunistic, insight-driven re-conceptualisation. In Chapter 4 of this thesis, which had subsequent publication as a conference paper (Raisey et al. 2006), we reported a first cycle of study of Creative Teams in action in which there was access to detailed data relating to the evolution of the focal artefact (in this case, a multi-year strategic research plan for the team), to the process undertaken by the team, and to communication between the team members.

In this chapter, we describe a subsequent study of this Creative Team in action. The task in hand for them was, however, slightly different this time: instead of developing a plan,

team-members focused on applying for funding for it; so the focal artefact was in the form of a grant application. The team was an expanded one, as several international experts and additional local research students had been recruited.

5.2 Conceptual Framework CF1 Revisited

Conceptual Framework CF1 is shown again on the next page as Figure 5-1.

We mentioned that a Creative Team is one comprised of 4–8 members and involved in creative work such as research, strategic planning, design, etc. Team-members work on an artefact and develop it (from version 1 to version *n*) continuously over the course of the project. In due course, the final version of the artefact will become the project's principal output.

The artefact follows an evolutionary–consolidating–revolutionary path throughout the project. This means that Creative Teams normally go through periods of incremental learning interspersed with periods of insight-driven re-conceptualisation, with pockets of minor reviewing or consolidation periods in between.

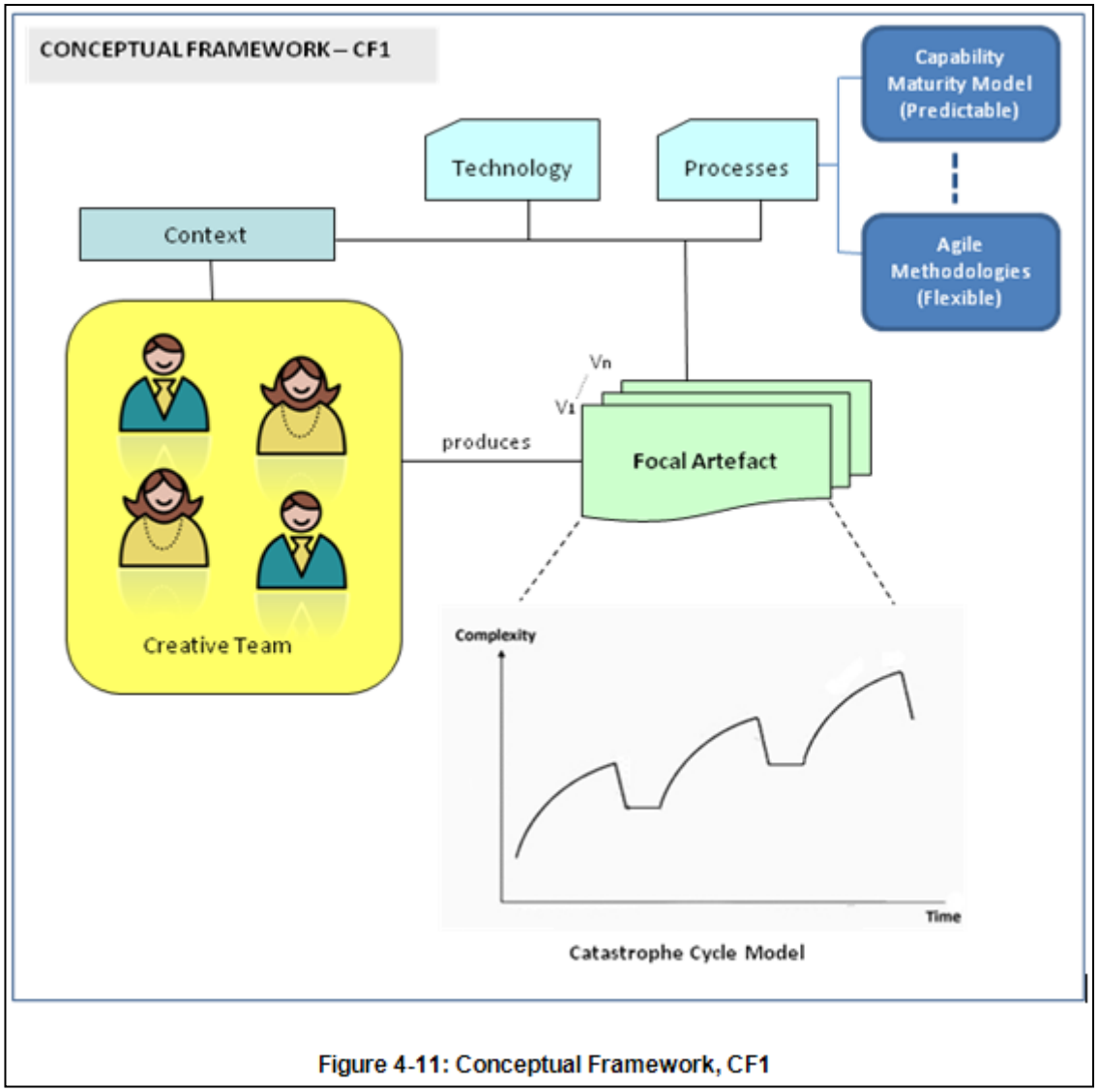


Figure 4-11: Conceptual Framework, CF1

Figure 5-1: Figure 4-11 re-presented

In reference to this CCM, we found that Creative Teams usually build upon their artefact until they reach a state of saturation; at that stage they try to re-conceptualise the problem and in doing so remove complexity or unnecessary 'noise' from the artefact. As discussed in Chapter 4 and in the literature (*cf.* Nguyen et al. 2000), in creative work team-members tend to be exposed to opportunities for change; and in changing they remove information that is irrelevant and so become more focused in their objectives.

In addition, we found that there was a consolidation stage in the artefact's evolution during which team-members were involved in evaluating the artefact as well as making certain minor revisions to it. In the case study provided in Chapter 4, the artefact was a strategic planning document; team-members were continuously involved in lower-level authoring processes such as formatting, correcting grammar and sentence structure as well as

rearranging certain paragraphs for smooth flow of text. Several researchers have mentioned this nature of work in their studies: for example, Flower and Hayes (1981) reveal that during this period authors read what they have written and evaluate/revise their text; Kellogg (1987) states that at this stage authors read text and detect errors in it; Bangert-Drowns (1993) mentions that there are lower-level processes in the authoring of a document that include simple editing (i.e., revision of grammar and spelling) and text rearrangement.

In the top right corner of Figure 5-1 are seen two contrasting approaches to managing teams that have been widely accepted: the first is a formal, systematic approach of continuous process monitoring and refinement, and the second a flexible and responsive way of dealing with changing client requirements of the environment. We examined in Chapter 4, using examples from the software engineering domain (CMM and agile methods) how these represent, respectively, a control-based and a flexible process: there has been ongoing discussion of (and calls for moderation regarding the tensions between) these contrasting process management approaches (Boehm 2002; Paulk 2002; Harris, Hevner & Collins 2006; Turner 2007). We explained that a proper team-based creative process is one in which team members, while conforming to a professionally-driven heuristic, have an attitude characterised by opportunism and insight, regardless of whether or not they have adopted a severely-controlled, predictable process or one agile in nature. Good leadership is shown when a team is competent in managing the delicate balance between predictability and flexibility.

In this chapter, the second cycle of study will be reported. The work involved conducting the second real-life full observational (activity-trace and focal-artefact-dynamic recorded) case study of a creative team at work in the context of the CCM. The main aims of the study reported here were:

- to discover if there was further evidence to support or to call into question previous observations of the Catastrophe Cycle Model (Nguyen, Swatman & Shanks 1999; Nguyen & Swatman 2003), or of the previous chapter, in creative teamwork;
- to observe long-term collaboration in which a Creative Team was involved in a continuation of their previous work.

The opportunity to be embedded within a team and study its unsimulated output across two connected projects, each undertaken over a period of months, is rare: seldom is there

reporting on studies of longer-term collaboration, where a team's progress is explained over the span of several projects.

A snapshot of a single project may be considered insufficient to meaningfully describe a Creative Team's performance, as it represents only a small fraction of the team's development dynamic; in practice, however, the situation studied is the norm, not the exception. For example, in an organisation's strategic planning activity, a team almost identical to that studied here will be involved in reviewing and planning the organisation's direction in each planning cycle unless there is a drastic change at top management level that dictates its being changed; while in the research domain, scientists seldom identify a new research direction each year — proceeding, typically, with the earlier ideas in evolved, adapted or enhanced form. In organisational theory it has also been found — as researchers often stress — that there is a need to study the concepts of exploration and exploitation in tandem (March 1991; Audia & Goncalo 2007). An organisation can be involved in the exploration of new ideas or the exploitation of ideas already developed — 'exploration' dealing with that aspect of experimentation that discovers new ways of doing things, and 'exploitation' focusing on refinement and extension of pre-existing ideas.

In a nutshell, we attempted to study how a team (very slightly different on the two occasions) performed during two unique but interrelated projects; for there is a need to learn from empirical evidence how a team improves or extends the design once a problem domain has been mostly explored. In the long term, our objective was to draw on these studies to identify useful ICT support for Creative Teams, as well as to evaluate the effect of the implementation of the proposed ICT intervention.

Because the underlying process is inherently creative, a Creative Team 'makes' the freedom to choose a variety of processes and technologies to assist them while producing their output, the focal artefact; it appears important that their work should be unconstrained by the processes or technology chosen.

5.3 Planning and Preparation

This research is founded on the studies of creative processes in requirement engineering teams (Nguyen, Swatman & Shanks 1999; Nguyen & Swatman 2003), leading to:

- a conceptualisation of the process as an inherently creative one, naturally comprising periods of incremental learning interrupted by periods of opportunistic, insight-driven

re-conceptualisation (the Catastrophe Cycle model in Figure 5-2 illustrates this idea); and

- a perception that the insights gained from this research were a consequence of the application of an immersive, observational and participatory research method; this highlighted significant weaknesses in traditional problem-solving and modelling approaches when applied to the investigation of unstructured (process role-fluid or goal-fluid) problem contexts.

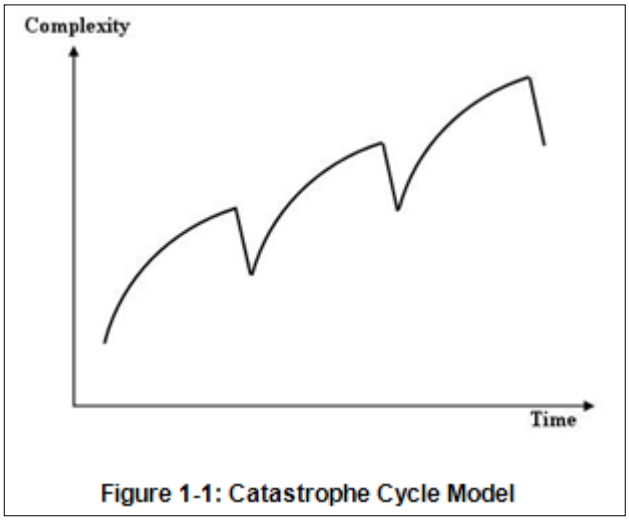


Figure 5-2: Figure 1-1 re-presented

The objectives of the research were to generate a dynamic model of focal artefact development, interpret the model, and compare and contrast it with the previous research. The approach undertaken was interpretivist in nature. We:

- collected characteristic data from and constructed a detailed model of the dynamics of the team's focal artefact;
- analysed the communication record between team-members;
- interviewed team-members to obtain their thoughts; and
- discussed focal artefact dynamics, using both communication records and interview data to build an interpretive lens.

We adopted an artefact-based approach of describing the processes of this Creative Team because researchers usually develop externalisations to express a solution to a problem (Yamamoto & Nakakoji 2005). Here, the key externalisation of the team was in the form of the grant application document that acted as the focal artefact in our study — i.e., the focal

artefact was a surrogate for the solution being developed by the team. Therefore, in order to describe the process, we needed to monitor and describe the focal artefact development.

The case studied in this research was the development of a grant application document, to be submitted to the Australian Research Council's 'Thinking Systems' grant in 2006. The goals of the research this grant was intended to fund were reasonably defined; the task of the team was to present the objectives in a fluid manner befitting the requirements of the funding; the nature of the project under study was that of a semi-structured problem.

Studying this project had the advantage of being a study of real work done by real people for real — i.e., professional — purposes. While studies in artificial environments may yield interesting results, their applicability to the real world is uncertain and thus their utility easily challenged; but they are easy to establish in a research/university setting and, consequently, dominate the literature. It is with this in mind that our research programme sought (and will continue to do so) to base empirical studies in the real world.

5.4 Case Description

The project observed was a grant application venture by a multinational team of researchers over a period of four months. Working on the basis of the strategic research plan developed previously (Raisey et al. 2006), the team leader believed that an injection of funds was necessary to take the project up to the next level. The focal artefact in this case, therefore, was a grant application document in Word (.doc) format. The team leader set the objectives and direction of the application, but obtained a considerable amount of input from his partners — in other words, the team leader coordinated the project.

Seven team-members in total were situated across three countries, worldwide. After the initial face-to-face meeting in a single location, the team became geographically dispersed, choosing to communicate primarily through email. They then focused on constructing the focal artefact document through asynchronous collaboration and review. The team decided to use Basic Support for Collaborative Work (BSCW) (www.bscw.de), a Web-based collaborative software, as the main workspace, using it to store important documents related to the project as well as all versions of the focal artefact. Any author making changes to the grant application document would create a newer version of it that incorporated them. The team leader would then made further edits to that version if necessary and store the version in BSCW. The detailed model of the development of the focal artefact would then be constructed for analysis. The exchange of emails and files were also captured. At the end of

the project, when the grant was submitted, the team had collected a total of 14 different versions of the grant document.

The process had been:

- data-collection of the artefact dynamics over time;
- construction of a detailed model of the focal artefact dynamics;
- analysis of the communication records between team-members;
- interviews of team-members to obtain their thoughts;
- discussion of the focal artefact dynamics, using both the communication records and interview data.

5.4.1 Construction of the focal artefact dynamic model

This section represents Section 4.5 in a summarised form with minor modifications; some of the content does not reappear where its inclusion would be merely repetitious.

To develop a dynamic model of the artefact, the information content or complexity of the artefact had firstly to be measured. In this research, we adopted a concept mining approach by using Leximancer (Smith 2003; Smith & Humphreys 2006), a software package capable of automatically identifying the number of concepts within a text corpus and the relationship between them. We took this approach because the focal artefact is a text document and Leximancer could provide an unbiased and consistent means for us to analyse it.

Leximancer creates a two-dimensional matrix labelled along each axis with the names of all concepts found. The main diagonal contains the number of occurrences of each concept within the text corpus, while the remaining cells of the matrix contain the number of pair-wise co-occurrences of concepts. This data can be represented as a multiply-connected graph (each unique concept representing a node, each pair-wise concept co-occurrence representing an edge), and a single value representing the complexity of a version of the document can be calculated. Finally, these values can be graphed to provide a picture of the dynamics of complexity change over time. For this case study, the Leximancer "number of concepts to be identified" parameter was set at 50, As mentioned in Section 4.5.3, there was no significant difference in shape between the two graphs – one graph in which the parameter was set to 50 and the other in which the parameter was set to 140. We chose to keep the value low by setting the parameter to 50 in Cycle 2 (this chapter) and Cycle 3 (reported in Chapter 6).

Specifically, the approach taken was thus:

- the entire corpus of 14 versions of the focal artefact document was subjected to automatic Leximancer analysis; Leximancer provided numerical values for the number of concepts and the number of links between these concepts in the form of a concept matrix for each version, and was instructed to store the concept matrix;
- for each version the complexity measure in accordance to graph theory was calculated, the complexity measure being Ew + N, where N represented the number of unique concepts (as nodes), E represented the concepts that co-occurred (as edges) and w the number of times they co-occurred; and
- a development model in the form of a complexity graph was constructed for the different versions of the focal artefact.

To interpret and derive the complexity graph, we drew on the contemporaneous communications record of team-members and on post hoc interview data, using methods similar to those described in Section 4.5. Semi-structured, face-to-face interviews were conducted with several team-members to find out what happened during each stage of change and why certain parts of the document had been altered at certain times. A more informal approach to interviewing was used because we wanted not only to guide the interviewee towards an exploration of the subject matter underlying the questions, but also to provide enough flexibility for us to probe his/her feelings and understanding of a given situation.

5.4.2 Results and Discussion

Figure 5-3 on the next page shows a summary of what occurred during the development of the grant application in terms of the complexity measurement from Leximancer, the insights obtained from the interviews and observation of communication records.

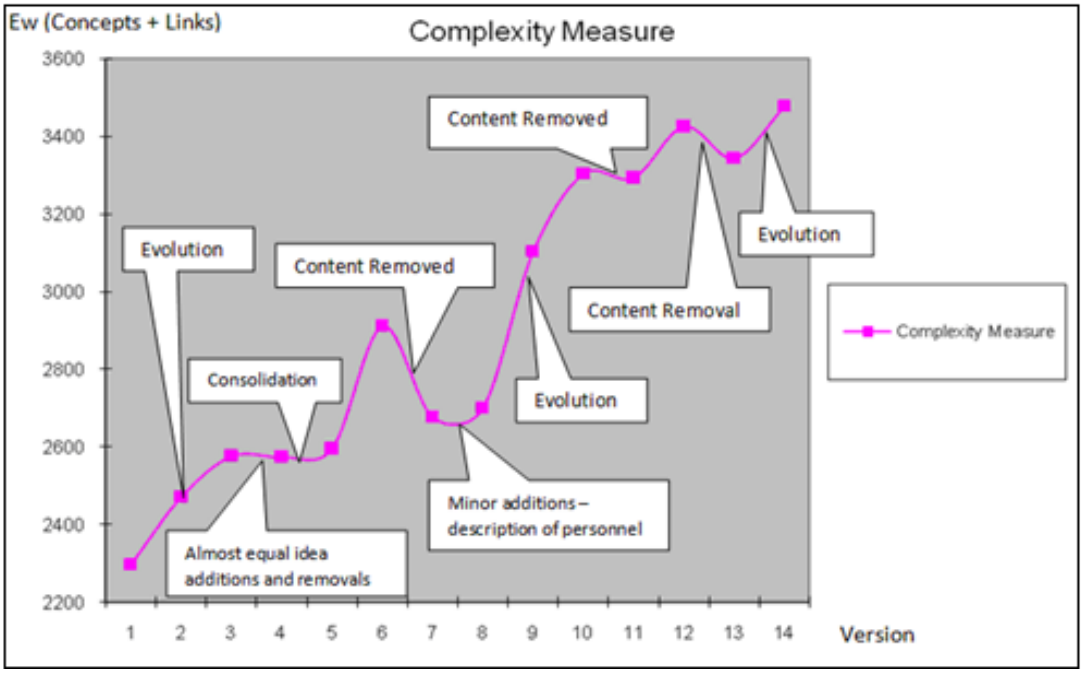


Figure 5-3: Complexity Measure with Annotations

In summary, there were three characteristic phase types in the dynamics of the focal artefact:

1. **Evolutionary**. In the evolutionary stages, concepts were added to the document. This was the period when ideas deemed viable at that point of time, having been discussed among team-members, were inserted into the focal artefact.
2. **Revolutionary**. In the revolutionary stages, there was a net concept removal from the focal artefact. Primarily, the removal occurred because the authors discovered that the concepts did not fit the requirements of the application, or they wanted to focus more on content that mattered by discarding extended ideas.
3. **Consolidation**. In this period, the changes were minor in impact, with most occurring in grammar and writing style. The purpose of this stage was mainly to simplify the presentation and make the text easier to read.

Interestingly, the evolution–revolution–consolidation phase pattern was consistent with that observed in the preceding cycle of this research, as shown in Chapter 4. This subsequent study served to strengthen the hypothesis that the Catastrophe Cycle Model forms a useful descriptive/analytic framework for creative teamwork.

5.4.3 Process Description

We begin with a step-by-step description of what occurred during the development of each version of the focal artefact.

Version 1 (v1) of the artefact contained information that was reused from some of the sections of the previous outcome (the strategic plan), with the content being formatted according to grant application layout.

In v2, the section on Expected Outcomes was expanded. Content on enhancing the way Creative Teams work and modelling the creative teamwork, as well as on the means to achieve that via a requirements engineering approach, was added. Further, the national significance of the project — the promotion of smart information use and innovation culture and economy — was elaborated on.

In v3, the scope of the project was explained in detail: in particular, situations in which this project aimed to provide support were explained. The scope was classified as 'same time, same place', 'same time, different place', 'any time, formal place', and 'any time, any place'.

In v4, content was both added and removed. Additions of content were made in the Background section, where the explanation of key concepts was added. On the other hand, the Research Plan section was tightened: specifically, elaboration on challenges to Creative Teams was moved to the Background section; while the concepts of requirements engineering and grounded theoretic approaches were removed from the section on Significance because they were not relevant to the focus of the application. Content on the nature of unstructured/semi-structured teamwork was also removed from the Innovation section because the idea was already discussed in an earlier section.

V5 was a largely cosmetic revision. The lead author consolidated the text by initiating minor changes to the writing style.

Considerable content was added in v6. The researchers added key strategies on how the results of the study would be presented and diffused (section on Communication of Results), and some extensions were made to the description of research team personnel.

In v7, a great deal of content — specifically, the description of different software engineering models (GOMS, Discrete Event Systems, Syntactic Representation) — was removed from the Methodology section of the application. Paragraphs describing the capture of various types of data — social interaction, artefact development, technology-mediated

interaction — were also removed. From the interviews, it emerged that the researchers drew on their existing knowledge when writing the first version of this grant application, and some elements of this knowledge could be found in the strategic plan; so whilst they had begun by stating their existing ideas, in this revision they adjusted the ideas once the vision was clear. One researcher provided an analogy for this situation:

> When you need to fill a hole in the wall, you plaster cement over it, and it (the amount of cement used) is more than you need to fill the hole. Then you begin to sand and polish it to fit.

The researchers wrote the Methodology section as best as they could during the first version. However, in v7 they had to prune the concepts to keep the application focused; and in doing this they felt that a lot of unnecessary 'noise' was removed from the presentation.

In v8, the Description of Personnel section was further expanded. The change was relatively minor, the role of each team-member being briefly mentioned. In addition, there were two inconsequential grammatical changes.

In v9, major additions occurred in the form of theories on situated action, distributed and external cognition and creativity. Also, the research was divided into smaller tasks that could be undertaken by postgraduate students. The workload of each student was elaborated. The Communication of Results strategy was also extended and elaborated. Three strategies had been identified originally: in this revision the researchers added three more strategies but removed an earlier one.

In v10, a lengthy discussion of prior work in Creativity was added. The significance of enhancing the creativity of the workforce was discussed at length as motivation for the research.

In v11, the discussion of GDSS was extended to describe technological support for convergence and the development of consensus. The researchers also formalised the structure of the argument within the proposal, discussing and adding new ideas and concepts (the information was added to accommodate team-members' responses to an email request from the team leader). In addition, there were some changes to the presentation/writing style.

These are primarily evolutionary activities.

In v12, further attention was paid to presentation of the ideas; some language was tightened, terminology and grammatical structures revised and references were added to support some existing arguments.

In v13, there was fairly major removal of material:

- in the Prior Work section, technological support for convergence and development of consensus went, as well as decision support concepts;
- in the Innovation section, structured decision-making in GDSS and potential solutions to the weaknesses in Creativity, HCI and Requirements Engineering-driven research in CSCW were removed;
- in the Investigators section, the design of a requirements engineering method, Formal Object-Oriented Methodology (FOOM), Object-Oriented Programming (OOP) and Checkland were removed from a researcher's profile: in fact, concepts related to software engineering such as FOOM and OOP were now deemed irrelevant to the focus of the application and removed entirely.

According to the researchers (in subsequent interviews), the changes were presentational in nature, designed primarily to improve the focus of the paper. At the time, they were focused less on the underlying programme of research than on presenting the application in such a way as to give them the best possible chance of meeting the objectives set forth in the grant guidelines. This was confirmed by the interviews and also the email exchanges amongst team-members.

In v14, there were significant changes:

- in the Prior Work section, some text with regard to the contribution to the CSCW community was removed; and a paragraph devoted to explaining the concept of functional creativity was also deleted;
- in the Innovation section, content on Requirements Engineering was removed;
- conversely, the Investigators and Description of Personnel sections were expanded, and the profiles of several researchers were added and descriptions of others elaborated;
- there was a number of grammatical changes to the text.

Overall the focus remained presentational: the researchers were trying to tighten the language and express their ideas more clearly.

5.4.4 Comparison with the first Cycle

We now compare the focal artefact analyses of both cycles, the first focusing on the development of the team's original strategic research plan (Chapter 4) and the second, reported in the previous section of this chapter, on the development of an application for research funding for later conceptualisation of a project derived from this planned programme.

It is important to note that there was a 6-month interval between the two cycles of the project; and the core researchers from the first cycle did not continue with the grant application that followed setting up the strategic plan.

Figure 5-4 on the next page shows the combined graph of the characteristic focal artefact dynamic.

We make two observations from this graph:

1. The peak-to-peak amplitudes of the two graphs are different. The first has a peak-to-peak amplitude of 2300 concept links whereas the second has a peak-to-peak amplitude of 1200, approximately half the value of the first. To recap, the core members of the Creative Team were brought together for the first cycle, when the team's focal artefact was a strategic plan. In that cycle, team-members were actually in the stage of exploration, where they explored the problem domain thoroughly and formulated an overall plan on how to address the problem. Therefore, more effort was spent on restructuring the problem domain, which resulted in bigger changes in the concept sets for the documentation.
2. There is a significant difference in the starting points of the graphs: the first cycle graph starts at 470 concept links while the second starts at 2250. This is because an *almost* similar team embarked on a different project six months later — a grant application project of which the focal artefact was in the form of a grant application document. At this stage, the researchers were more or less familiar with the problem's structure because of their previous effort. For them, most of the building blocks for the document were available, and the aim was to shift those blocks around to build a coherent story to the best of their knowledge. This was more of a design problem: how to achieve focus and garner the best result in getting the grant application approved. In

other words, the problem was better-structured in the minds of the team than it was in the first cycle. This time, the team was more concerned with the exploitation of ideas that they had already produced.

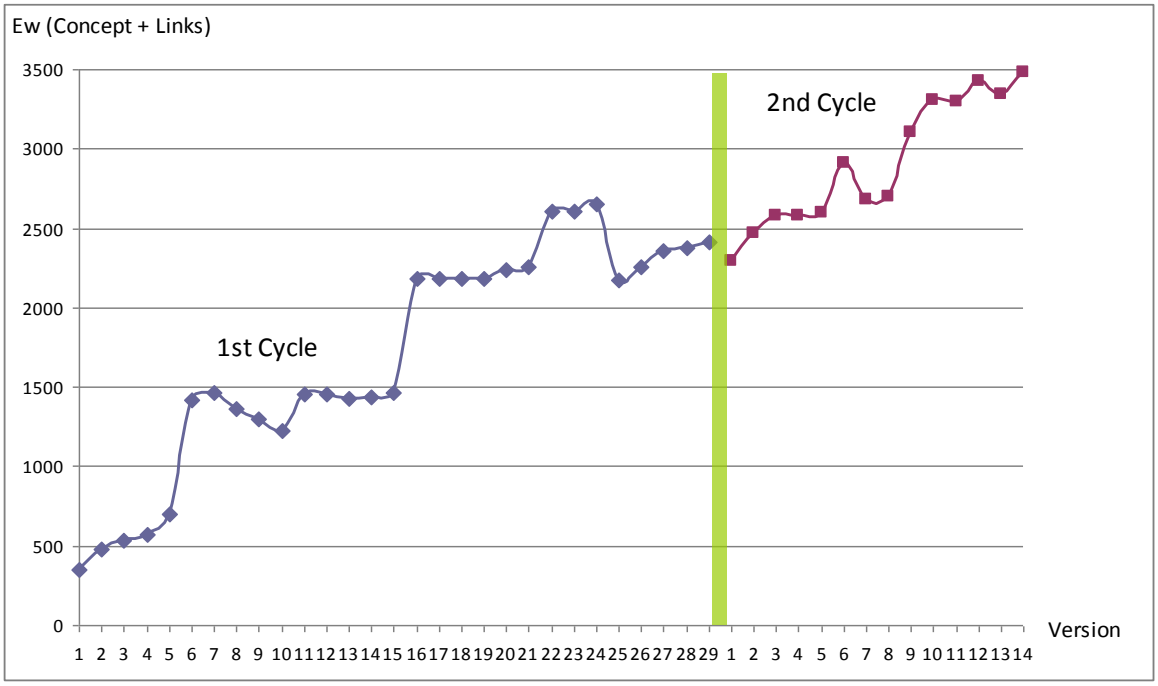


Figure 5-4: Superimposed Graphs for the First and Second Cycles

5.5 Cycle Literature Review: Exploration versus Exploitation

From the comparison results obtained, we found that in two projects with similar themes researchers had the tendency to exploit ideas developed in the course of the earlier: one would expect to find somewhat less reconceptualisation in the second cycle of work on a problem. As this continued on with the understanding of the nature of problems faced by Creative Teams, the problem domain was fairly well established. And as the structure of the problem conceptualisation resolved, we expected (and found) fewer and less intense (lower amplitude) periods of problem reconceptualisation. An analogy can be found in a game of soccer: when a player first learns the game, s/he learns the mechanics of kicking a ball; later, the kicking technique becomes the norm and is embedded in the subconscious mind of the player, so that instead of thinking about the mechanics of kicking, s/he can focus on ball placement. Reconceptualisation is not eliminated: rather, the level of abstraction at which reconceptualisation occurs is raised.

An insightful paper by March (1991) describes at length the concepts of exploration and exploitation in organisations. In the exploration phase, researchers or organisations frequently

experiment with new methods to establish new paradigms, novel ideas or solutions; conversely, exploitation focuses on refinement and extension of pre-existing paradigms, ideas or solutions. Gilsing and Nooteboom (2006) describe exploitation in organisations as a form of consolidation into an influential product offering, which results in market stability and increased consumer demand. To compete better in this mature market environment, organisations shift their focus from providing further product innovations to improving their business processes — such as enhancing production and distribution mechanisms.

March (1991) also points out that once a researcher develops new ideas and experiences success with them, s/he will try to exploit the ideas that made him/her successful rather than develop new ideas. For example, Art Fry, the inventor of the Post-it Note, created other products that revolved around his original idea — the Post it Pop-up Note Dispenser and the Post-it Flag.

Audia and Goncalo (2007) study the development of inventions in the hard-disk drive industry through an analysis of the patenting history of major hard disk manufacturers, and observe that successful researchers are less inclined towards exploring new domains of research; they would prefer to build on their current knowledge base, and therefore their ideas tend to be more incremental than divergent in nature. They also argue that incremental ideas "have less impact in their field" based on the frequency with which these ideas are cited by the community.

The question is: will there be a negative effect if organisations focus too much on exploitation rather than on exploration? According to some researchers (March 1991; Gilsing & Nooteboom 2006) the answer is yes — it will be detrimental to organisations, especially in the long run. An organisation devoid of new ideas is considered 'technologically bankrupt', potentially overtaken by newer entrants, more agile and adaptable to market conditions.

Conversely, Lee et al. (2003) present another perspective on this issue: some organisations could actually prosper by exploiting available technology rather than by adopting/exploring a different strategy. If the organisation has a large base of clients accustomed to using to a particular technology, a better, incompatible technology may not be appealing to them. An example provided in the literature is Intel: in the 1990s, Intel chose to use the established complex instruction set computing (CISC) technology rather than the more advanced reduced instruction set computing (RISC) technology in their processors, simply because their customers were too familiar with the older technology.

5.6 Conceptual Framework CF2

The conceptual framework from the beginning of this chapter was updated to become CF2. The cycle literature review on the themes of exploration and exploitation and the comparison between cycles 1 and 2 were used to form CF2. The updated framework is shown below in Figure 5-5.

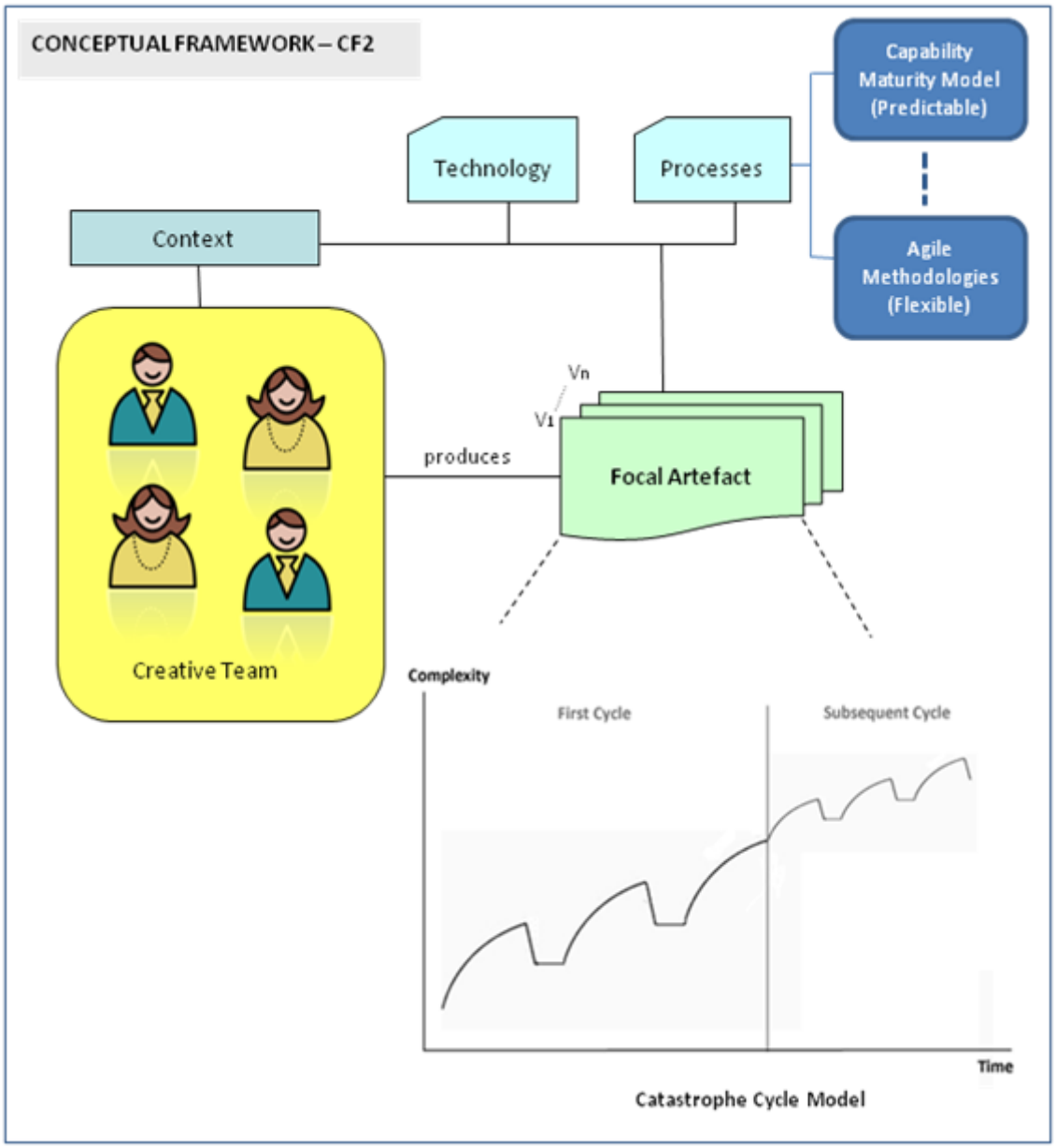


Figure 5-5: Upgraded Conceptual Framework - CF2

The findings from the analysis performed in Cycle 2 not only strengthened what we stated in CF1, but further extended the CCM.

We have modified the graphic by adding a subsequent graph for a follow-up project. As shown, the graph of this second cycle is of a lesser magnitude than the graph of the first cycle. We postulate that once a team has become familiar with a problem domain through work experience, a follow-up project will allow them to exploit their previous efforts. Although the same evolution–revolution–consolidation phases can be found in the artefact dynamics, these phases are of a lesser amplitude than the previous cycle's. The problem the team is trying to solve is definitely more structured than it was when they started out.

This conceptual framework will form the basis for Chapter 6, which describes the team's starting to prepare a report of the research conducted.

5.7 Conclusion

The contribution of this chapter is fourfold. Firstly, as mentioned earlier, Shumarova and Swatman (2008b) discovered that formal CITs lack impact in organisations, suggesting that there is a distinct lack of understanding in collaborative teamwork for the forming of an appropriate foundation for the development of CITs, so that it is unlikely there will be effective support of such work. By solidly grounding our research on observational work of experts in the real world (the four principle researchers involved in the development of the second cycle grant application were vastly experienced, having more than 700 refereed publications between them), we have the evidence to claim that Creative Teams work in a non-linear fashion, heuristically guided but, at a detailed level, rather unpredictably. There is an evolutionary–consolidating–revolutionary pattern to their working processes.

Consequently, support for Creative Teams must be contingent upon the situation they are facing rather than imposing rigid, formalised structures and procedures. We believe that CIT support is likely to be most effective if the team is given the flexibility to react according to the situation — you might say, provided with a flexible toolkit containing a variety of tools that can be used by team-members to respond to different problem situations and different team environments..

The second contribution of this chapter is the discovery of further evidence to support the concept that the Catastrophe Cycle Model forms the basis for describing subsequent cycles of the creative process. In a follow-up stage in which the problem domain is relatively well-known (compared with the first stage), teams depended on past experiences in solving such problems and therefore had the tendency to exploit existing ideas rather than venture out to explore new problem domains. The first two contributions addresses thesis objective O1

The third contribution is in regard to the decay in the amplitude of alterations in the graph of the second cycle. The potential danger of rigidities forming in a team's processes as time goes on presents a challenge to team management; and it would be wise for management to periodically refresh the team to retain its capability and flexibility. (For example, in the academic world a university constantly sends lecturers on sabbatical, where they get to exchange knowledge and undergo different experiences in another environment. Upon return, the lecturers have better insight into the research in hand, and will have a better perspective on problems they need to address.) The updated Catastrophe Cycle Model has the potential to provide a team with ample warning when the team goes into full-exploitation mode. This contribution is tightly related to thesis objective O3, in which we discuss the implications of the model and intervention strategies.

Finally, we demonstrated a strategy that allowed effective analysis of the developed path of a focal artefact, deriving explanation of the process from the examination and analysis of communication records supplemented with post hoc interview data. In this case we developed a metrics strategy for an artefact which was, in effect, unstructured text. Each class of artefact will require its own approach to metrics collection; but, we argue, that we were able to do so satisfactorily for an unstructured artefact represents proof-of-concept offering a reasonable level of confidence in generalisability. This follows closely in addressing thesis objective O2.

6 Creative Team Dynamics: Report to Funders

6.1 Introduction

Revisiting the contextualisation of the problem in Chapters 4 and 5, we find that understanding team-based creativity is essential for the IS Community. Extensive studies into CITs by IS researchers have identified a real world need for CIT-based support for creative teamwork, but a lack of understanding of its nature — and thus there is a lack of diffusion of research outcomes into practice. This chapter aims to further enhance our understanding through an observational study of a team working on a follow-up problem.

In this thesis we observed a Creative Team undertaking a series of three events within an overall project framework. The first cycle of the study (Chapter 4) focused on the Creative Team's starting out on the project. Then the team started to develop a strategic plan for its research (which plan was also published as a paper at a conference). The nature of the problem was still poorly defined, and could be characterised as a creative problem. What we achieved in our observation of that cycle was twofold:

1. our findings solidified the theory that teams follow the pattern of evolution–revolution as suggested in the Catastrophe Cycle Model; and
2. an additional stage, known as the consolidation stage, was discovered in the Catastrophe Cycle Model.

This intermediate stage only appeared when there were minor edits to the focal artefact (mostly cosmetic in nature) but the structure and the flow of the document remained the same.

The findings of Cycle 1 resulted in the modification of the existing conceptual framework to CF1.

In Cycle 2 (Chapter 5), we recommenced our observations of an almost similar team — i.e., the core group of the Creative Team in Cycle 1 with the addition of several renowned international researchers — but on this occasion the team was involved in a grant application exercise. We found further evidence that the team worked in an unpredictable way at a micro level, even though its members were initially guided by what appeared to be a well-defined and largely linear plan. The evolutionary–consolidating–revolutionary pattern was certainly prevalent in their working processes as reflected in the CCM; however, we discovered something interesting when we compared the complexity graph of Cycle 2 with that of Cycle 1: the attenuation or amplitude of change in the graph for Cycle 2 was less. This indicated that

in any subsequent cycle of study in an overall project, the problem space will undoubtedly be better defined compared with the time at which a team starts out; team-members are able to draw from their initial experience and knowledge to solve the task in hand. And our team wanted to exploit the fruits of their Cycle 1 labour, resisting venturing out to explore new problem domains.

In this chapter we report our findings from the final cycle of research into a Creative Team, Cycle 3. As in Chapters 4 and 5, we begin by discussing the most recent conceptual framework — CF2. Then we explore the methodology used to gather and analyse the data, which is very similar to the methods used in Cycles 1 and 2. The results and analysis sections are shown, accompanied by a developed complexity graph. The graph is then compared with those found in Chapters 4 and 5, to determine if the amplitude of change is less than those of the previous cycles.

We see that the shape of the complexity graph was within our expectations. However, what we did not foresee was that a researcher described during interview an interesting experience that had happened during the project; the experience was explored further, and led us to re-examine the literature as well as the previous two cycles. This resulted in the mini-literature section and an updated conceptual framework, CF3.

6.2 Conceptual Framework CF2 Revisited

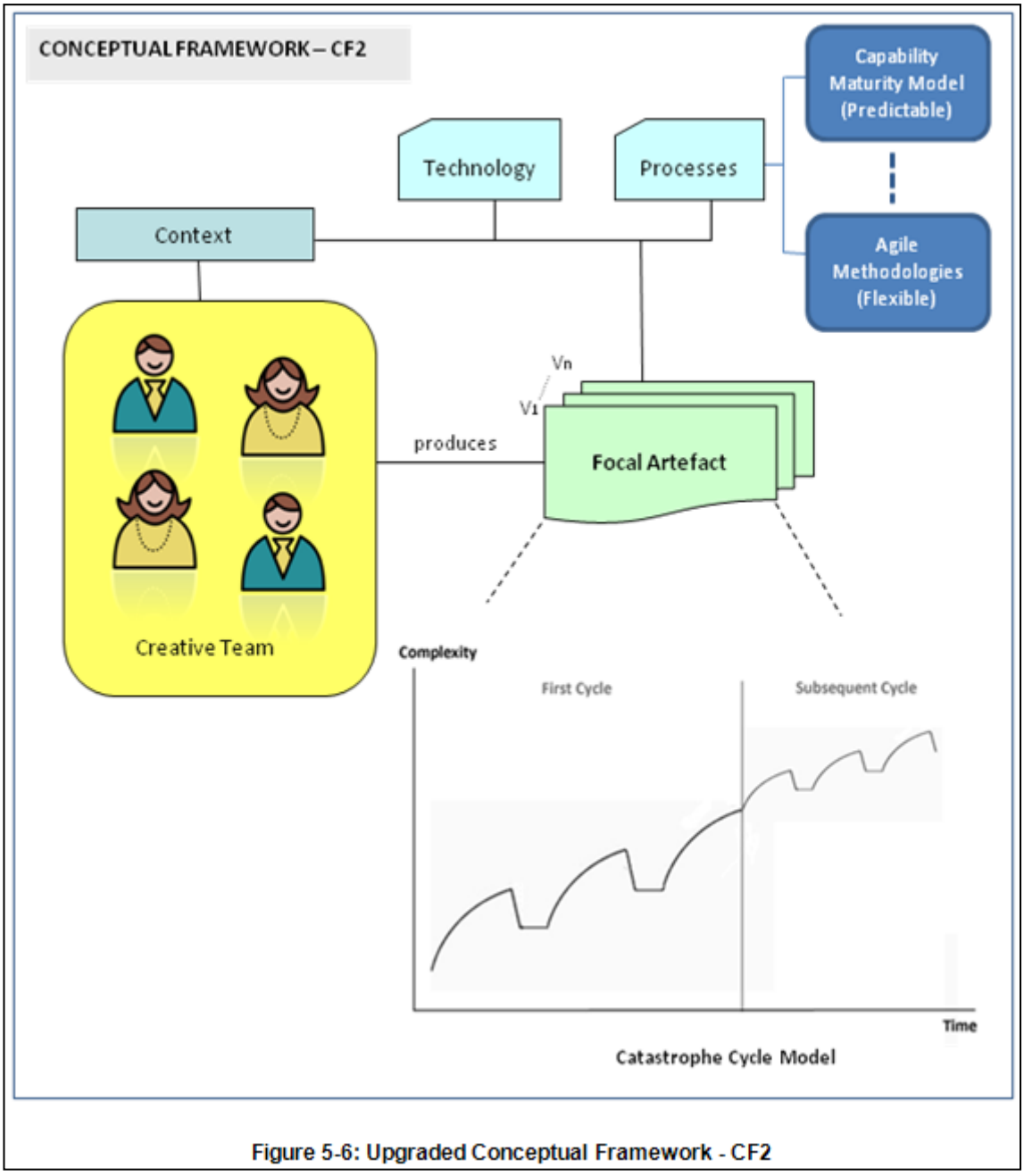


Figure 5-6: Upgraded Conceptual Framework - CF2

Figure 6-1: Figure 5-6 re-presented

Figure 6-1 shows the conceptual framework that we inherited from Chapter 5. As now understood, a Creative Team in the context of this thesis is a team that contains 4-8 members, who work on solving ill-structured problems (such problems being prevalent in research, military command and control, requirements engineering teams, etc.). Also, the teams can be managed using predictable approaches such as CMM, or more flexible, responsive approaches like agile methodologies. Because the underlying process is inherently creative,

the team ‘makes’ the freedom to choose a variety of processes and technologies to assist them while producing their output, the focal artefact. The team agrees that their work should not be constrained by the processes or technology that they chose to use.

Over the course of this project, the team would work continuously on a focal artefact over several versions (v1 to v*n*) until the final version of that artefact was produced. The focal artefact did not follow a linear path as initially expected, but instead an evolutionary–consolidating–revolutionary path: team-members developed the focal artefact, refined it, and at times achieved certain insights (such as thinking of a new way to present their document) that caused them to reduce the artefact’s content. In addition, the amplitude of evolution–consolidation–revolution in the complexity graph would slowly tone down over the course of the overall project. Because of familiarisation with the problem and a tendency to resist change, the team was likely to go into ‘exploitation’ mode. Subsequent project work would be much more predictable in comparison with that done when the team first started. With this in mind, we conducted our third and final cycle of study on the Creative Team.

6.3 Planning and Preparation

The objectives for this study remained the same. Specifically, we aimed to:

- search for further evidence to support the existence of the CCM in creative teamwork; and
- compare the complexity graph with previous versions and to observe the focal artefact dynamics of a Creative Team involved in a follow-up of previous work.

We mentioned in Chapter 5 that it is rare to have the opportunity to study real-life creative teamwork across two interrelated projects. Having the opportunity to observe the same Creative Team working on a third interconnected project within a larger project framework was indeed fortunate: we strongly believe that studies of long-term collaboration over the course of several projects are infrequent, making a panoramic view of the team dynamics across several projects a noteworthy contribution to the literature.

Using a method similar to that of Chapters 4 and 5, we first extracted the focal artefact versions stored in BSCW, the Creative Team’s shared workspace; as mentioned, team-members ensured that they stored all working documents on that server. Great care was taken in the storage of the focal artefact document: it was stored in a specific section of the server

and the versioning function of BSCW was turned on so that every time it was updated by a team-member, it would be stored as a new version.

We adopt an interpretive approach of research by

- collecting characteristic data from, and constructing a detailed model of, the dynamics of the team's focal artefact;
- analysing the communication record between team-members;
- interviewing team-members to obtain their thoughts;
- discussing focal artefact dynamics, using both the communication records and interview data to build an interpretive lens.

This will be explored further in the following sections.

6.4 Case Description

The third cycle of the project was the major (concluding) report to the funding body of the project.

The project was funded over three years, with the report to be submitted at the end of the period; and to be written by a core group of researchers similar to those involved in the first and second cycles. This time the research team consisted of seven members: two principal researchers, three postgraduate students, one research assistant and an editor who was involved in the reporting activity. The team did not include the multinational researchers from the second cycle because they were not recipients of the funding, and therefore not relevant to the production of the report.

The reporting activity consisted of continuous work by team-members over a period of three months. This third cycle of the project was very important, because the team needed to justify the way they had used the funding as well as provide details of the results they had obtained; further, they wanted to build on the opportunity to apply for the next cycle of funding from the funding body. The team communicated mainly via email, interspersed with sporadic face-to-face meetings.

In similar fashion to Cycles 1 and 2, they stored their working documents in a central shared workspace and repository, (Basic Support for Collaborative Work) BSCW: the focal artefact in this cycle was the reporting document. Team-members, again, continuously constructed the focal artefact through asynchronous review and collaboration; any team-member who made a modification to the focal artefact would save it as a newer revision. At

the end of the project, the team had collected a total of 16 different versions of the reporting document, so a model of the focal artefact dynamics was constructed from their compilation for submission of the report to funders.

The report was initially thought to be linear in nature, where the researchers simply reported on knowledge gained throughout the funding cycle. A preliminary interview with the team leader seemingly strengthened this assumption; to quote from him:

> The concepts are more or less fixed, so that document is about putting (the knowledge that was produced earlier) in the first instance, and modifying to fit the presentation (of the report).

However, there was an unexpected insight on the part of a team-member that caused a significant change in the direction of the team itself over the course of the entire project.

The reporting activity started with when the team was instructed, upon expiration of the funding cycle, to produce a report of their research results. This activity was initially described as

> a design of the presentation of results, finding a good way of telling the funding body what we have done with their contribution... it's a proposal rather than a piece of exploration. (Team Leader)

What he meant was that the team did not set out to discover new concepts or gain new knowledge. Instead, their duty was *to present their results* with as much clarity as possible — and, in addition, they wanted to use the report as a platform to request future funding.

Certain requirements had been listed by the funding body at the beginning of the research project, when the funding contract was signed. One major requirement was the delivery of six standalone reports, describing the six sections of the research project. However, due to the nature of the research project and the fact that there was much overlap of background material, the team leader negotiated with the funding body to deliver only a single report rather than writing reports on each of the sections. The negotiated terms became those of writing one report to contain the overview of the entire project, inclusive of all the background material (which would greatly reduce duplication). At the end of the report, appendices representing the six sections of the project would be added; and they would contain all the deliverables promised earlier.

An initial meeting was called about this report writing, and team-members discussed how best they could collaborate. It was decided from the beginning that the team leader would coordinate the activities of the others; he would assign specific sections or tasks to the various team-members.

> We share out all the work. So I build up a boilerplate for the content we are adding… it is reasonable in a project report the certain goals would have been achieved and the promised outcomes were accomplished ahead of time. But of course, (the report) does not read coherently because each paper was actually written independently. (Team Leader)

The team then focused on constructing the focal artefact through asynchronous collaboration and review. Any team-member could make changes to the any section as long as s/he notified the team leader; s/he would then create a newer version of that article, incorporating the aforementioned changes. Then the sections would be compiled by the team leader and put into the master document; and he would then store the version in BSCW, which could be accessed by all members.

The team leader, with the assistance of the editor, would conduct the majority of the structuring and formatting of the document. In addition, the team leader had to act as a stand-in for a researcher who was on a long service leave at the time the document was developed. When a reasonable draft of the report was prepared, the team planned to send it to external, renowned researchers in the area for feedback and comments.

The detailed model of the development of the focal artefact could then be constructed for analysis. The exchange of emails and files were also captured. At the end of the project when the grant was submitted, the team had collected a total of 16 different versions of the project report.

6.5 Construction of the focal artefact dynamic model

To develop the artefact dynamic model the information content or complexity of the artefact has first to be measured. In this research, we adopted a concept mining approach by using Leximancer (Smith 2003; Smith & Humphreys 2006), a software package capable of automatically identifying the number of concepts and the relationship between them from a text corpus. We took this approach firstly because the focal artefact is a textual document, and secondly because Leximancer could provide an unbiased and consistent means for us to analyse this document. Leximancer creates a two-dimensional matrix labelled along each axis

with the names of all concepts found: the main diagonal contains the number of occurrences of each concept within in the text corpus, while the remaining cells of the matrix contain the number of pair-wise co-occurrences of concepts. This data can be represented as a multiply connected graph (each unique concept representing a node, each pair-wise concept co-occurrence an edge), and then a single value representing the complexity of a version of the document can be calculated. Finally, these values can be graphed to provide a picture of the dynamics of complexity change over time.

Specifically, our approach was

- to subject the entire corpus of 16 versions of the focal artefact document to automatic Leximancer analysis;
- to have Leximancer provide numerical values for the number of concepts and the number of links between these concepts, in the form of a concept matrix for each version; and to instruct Leximancer to store the concept matrix;
- to calculate for each version the complexity measure in accordance to graph theory, with the complexity measure being Ew + N where N represents the number of unique concepts (as nodes), E represents the concepts that co-occur (as edges) and w is the number of times they co-occur.
- to construct a development model in the form of a complexity graph for the different versions of the focal artefact.

To interpret and derive the complexity graph, we drew on both the contemporaneous communications record of team-members and post hoc interview data, using methods similar to those described in Chapter 4, Section 4.5. Semi-structured, face-to-face interviews were conducted with several team-members to find out what happened during each stage of change and why they altered certain parts of the document at any given time. We used a more informal approach to interviewing because we wanted not only to guide the interviewee towards an exploration of the subject matter underlying the questions, but also to provide enough flexibility for us to probe his/her feelings and understanding of various situations.

6.6 Results and Discussion

In Figure 6-2, the complexity graph was plotted to show what had occurred to the focal artefact over the course of the development of the report. The graph was obtained from the Leximancer analysis of the focal artefact versions.

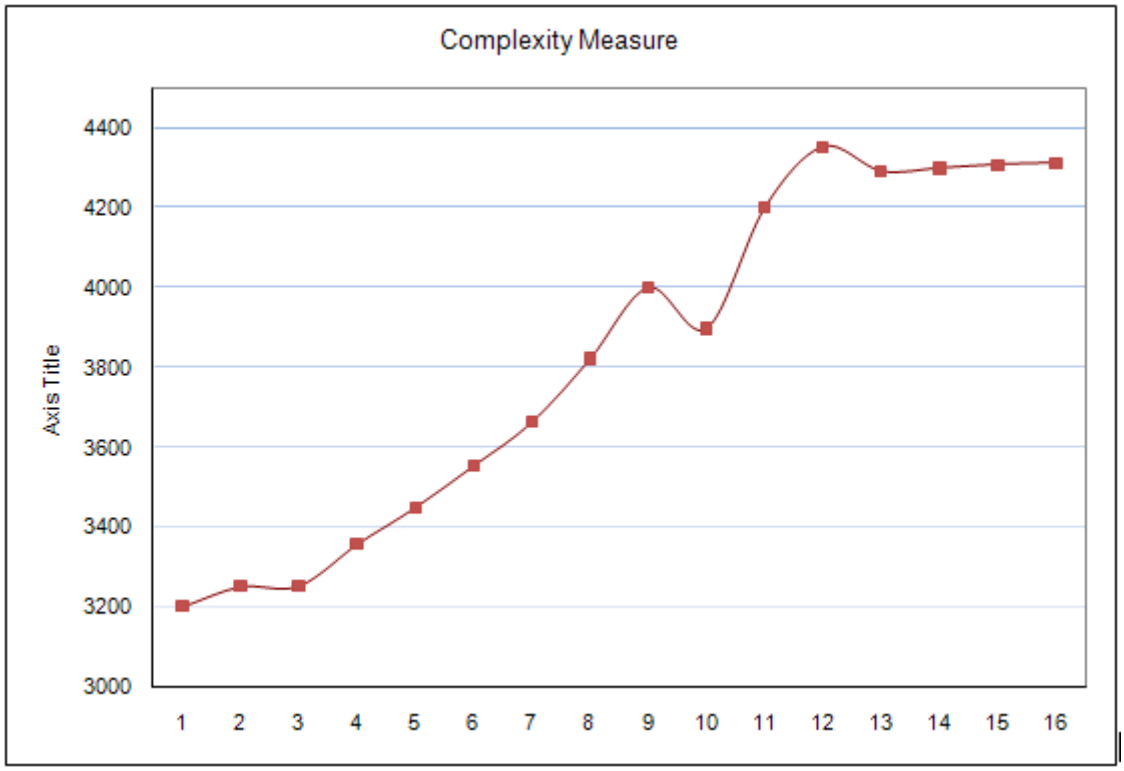


Figure 6-2: Complexity Measure with Annotations

In summary, there were three main characteristic phase-types in the dynamics of the focal artefact:

1. **Evolutionary**. In the evolutionary stages, concepts were added to the document. This was the period wherein ideas were discussed among team-members, deemed viable at that point of time and inserted into the focal artefact.
2. **Consolidating**. In this period, the changes were minor in impact, with most changes occurring in grammar and writing style. The purpose of this stage was mainly to simplify the presentation and make the text easier to read.
3. **Revolutionary**. Typically, in the revolutionary stages, there was net concept removal from the focal artefact.

This typical activity occurred in v9–v10 and in v12–v13. Primarily, the removal occurred because the authors discovered that the concepts did not fit the requirements of the application, or they wanted to focus more on some content by discarding extended ideas. To examine the evolutionary–consolidating–revolutionary phenomenon further, we conducted interviews with team-members and examined the communications record to discover the rationale of the dynamics of the graph.

6.6.1 Process Description

We began with a step-by-step description of what occurred during the development of each version of the focal artefact.

The report had been described as a design for the presentation of the results obtained over the course of a project. Ascertaining the best way to present the findings to the funding body was of primary importance; the key being the need to integrate all the established ideas into a master document, addressing all the issues required by the initial contract.

Starting from v1, the initial document of this cycle, the team gained a clear idea of the content to be inserted into the report after referring to the project requirements listed in the funding contract: their major concern, however, was how to direct the presentation of the content. Therefore, in this version, a skeleton structure of the entire document was created and a numbering strategy decided on: this determined how each section was to be numbered as well as the sequencing of the content.

The team-members then went ahead with compiling the work carried out during the life of the project. The literature review, the content for introductory background material to the report (inclusive of the project goals), was put together from their various publications throughout the project. There were underlying documents containing nuggets of information that could be reused as report content: in particular, the strategic plan developed by the research team in an earlier work (Chapter 4) was a focal point of discussion; and the team's grant application document (Chapter 5) provided a similar information pool.

In v2, the scaffold for the appendix was created. The team was to develop six appendices (A–F), representing the six reports initially negotiated by both parties — the researchers and the funding body — in the contractual agreement. An indexing footprint was also created for the content in the introduction section: the team came up with an index that linked each project requirement to a section in the report containing the specific information that addressed this requirement. For example, the following is an excerpt of the requirements and the related linkages in the report:

- ✓ report detailing review of modelling approaches for RES (Appendix A, Part 3); and
- ✓ report providing definition of evaluation criteria for RES-type model (Appendix B);

from which it can be deduced that Appendix A, part 3 contained information on requirement 1, the review of modelling approaches; similarly, information about requirement 2, criteria for a RES-type model evaluation, could be found in Appendix B.

Next, the content on requirements engineering was inserted into this version; and Checkland's Soft Systems Methodology was also introduced as content. This concept provided a starting point for the project and was also the section from the team leader; consequently, it appeared very early in the report.

The research assistant in the team had brought a wealth of experience and ideas; along with the team leader she introduced a key concept known as Exploration and Evaluation Harness (EEH). This concept has never been expressed before and was certainly unexpected. A diagram of it was developed, and this action sowed the seed for future change in plans. In the words of the team leader:

> I have to say it's an idea to be excited about. It was a good choice, (it is) just one of the things that changes your directions... We talked about it but this was the first time we made it coherent and structured.

There was only a minor change in v3. Because team-members used different word processors to write their content and some members were not familiar with the various models of word processor, the formatting was not done properly (e.g., where a section heading was required the text was to be styled as a heading rather than being merely emboldened by the word processor). The team leader had to standardise the formatting of the document; as well, to update the Table of Contents. These changes were purely cosmetic and had little impact, content-wise.

In v4, the concept of EEH was taken further. The team leader started to expand on EEH by describing how to use requirements engineering to deal with the problem of orchestration. The team was familiar with the concept but had not used it in formal writing, despite many rounds of team discussions. Team-members had not thought of presenting the report within this dimension at the start of the report's writing; so the major input here was that this version set up EEH to be an important component of the report. In fact, therefore, they created an entirely new explanation of it.

In v5, the team started working on the EEH concept. The content added in v3 and 4 was re-written to better fit the context of this report. After this activity they focused on the extension of EEH again, this time by adding 'narrator' and 'interpreter' elements. The

creation of theory-informed stories — another element of EEH — was described in depth. None of these elements had previously been discussed in such detail. Secondly, the 'cognitive dust' concept was modified for the purpose of this report: a few sentences were added to explain it. Apart from this, there were a few minor modifications in the document such as the update of Table of Contents and References.

In v6, Appendix E, which contained some project results, was added to the version. Once the team leader had received this section from a researcher, some minor modifications were made to it before it was added.

The last appendix, Appendix F, was added in v7; it contained previously-known concepts such as ontologies, databases and personal information management. In addition, the concept of an RES database was explained here. The discussion was on data-modelling strategies related to the RES. As well, a glossary was developed at this stage.

In v8, the concept of EEH was further expanded, and was disseminated throughout several other sections of the report: for example, appendices A and D were expanded significantly to accommodate this new concept and contain statements that were useful in the context of the report. According to the team leader, the EEH also served as a platform from which the team could apply for future funding. It was certainly useful to elaborate on the results of the team, but an even better outcome would prove to be that of establishing a rationale for future project work as well as future funding.

In v9, the researchers worked on expanding Appendix A further, following the work performed in v8. Because EEH had by then became the primary concept and expression, extensive discussion was required. The concepts of 'reporters', 'theoretically-driven stories' and 'selection of theories' were added to Appendix A to extend the EEH concept.

In v10, the EEH concept was reshaped to better fit the report. Because the team had added so much new content, a team-member suggested that some rethinking was required.

> Is all this content necessary? What content should we remove to make the report better? (Creative Team-member)

Apparently, other team-members agreed with him, and a number of paragraphs deemed unsuitable for the purpose of the report were removed: this was to ensure the report had a better focus on achieving the team's objectives.

In v11, Appendix C was added. Appendix C was sent to the team leader by a researcher who was working on the concept of cognitive dust; the concept was well-defined and had appeared in a publication before. The team leader had incorporated this concept into the report. However, the team leader noticed that Appendix C needed further expansion because of the introduction into the report of EEH. Two significant changes happened in v12:

1. The team leader worked on improving Appendix C to accommodate the concept of EEH. Evaluation strategies and the nature of collaboration were explored and added to Appendix C to make the cognitive dust concept tie in better with the new ideas.

2. The team-members had identified potential weaknesses in the research project and formulated plans for improvement; and by carrying them out, team-members hoped either to secure an extension of funding or to start a new funding cycle. All these plans were included in a section of the report called "Reflection and Future Work".

In v13, the team reflected on the changes they had made in v11 and v12. Some concepts that were deemed irrelevant in the report were removed, to achieve focus and clarity.

From v14 to v16, there were only minor changes to the documentation to create better flow. In fact, the majority of the work had been completed by v13: by this stage the team was actually focusing on applying final polishing to the documentation.

The report was also sent to external researchers for feedback. The feedback received was excellent: no modifications to the key concepts were called for. In addition, throughout this period, both the editor and the team leader checked for grammatical errors and irregular sentence structures, making changes when appropriate (these revisions were purely cosmetic in nature).

6.6.2 Comparison with the first and second cycles

In this section a comparison is made between the complexity graphs of all three cycles.

The first cycle focused on the development of the team's original strategic research plan (Chapter 4). The second cycle, reported in the previous section of this chapter, focused on the development of an application for research funding for a later conceptualisation of a project derived from this planned programme (Chapter 5). The third cycle, reported on in this

chapter, focused on the development of a report for funders. Figure 6-3 shows the combined graphs of the characteristic focal artefact dynamic.

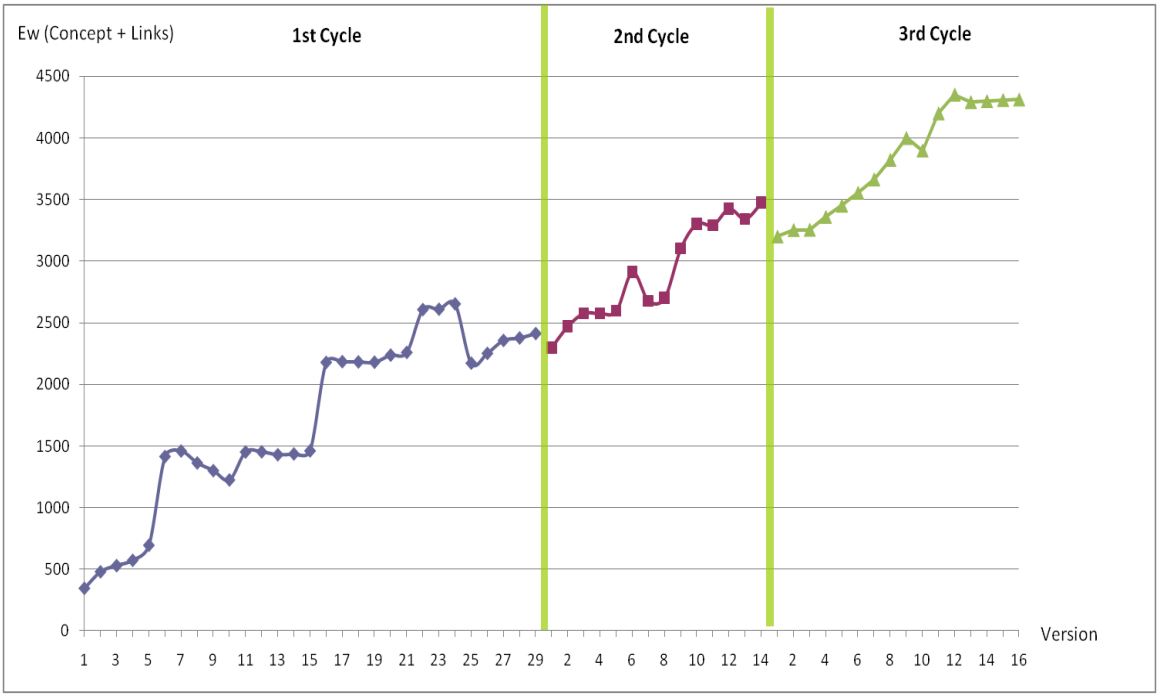


Figure 6-3: Superimposed Graphs of the 1st, 2nd and 3rd Cycles

The following observations of the third cycle graph can be made:

1. The starting point for the third cycle graph is at 3200 concept-links, in comparison with 470 concept-links in the first graph and 2250 concept-links in the second.
2. The peak-to-peak amplitude for the third graph is slightly less than that of the second graph but significantly less in comparison with the first. The third graph has a peak-to-peak amplitude of 1100 concept-links; the second graph has a peak-to-peak amplitude of 1200 concept-links; whereas the first graph has a peak-to-peak amplitude of 2300 concept-links.

From Observation 1, we can tell that the third graph seems to be a continuation of the second: this is due to the fact that the report to funders was developed using the basic building blocks established from the first and second cycles. During the third stage, team-members were already quite familiar with the problem in hand, and the problem structure was established in their minds. Continuing to use the exploration–exploitation paradigm, the team seemingly exploited the ideas it had embraced in Cycles 1 and 2, when it developed the report to funders — but with an exception…

Following Observation 2, the peak-to-peak amplitude of the third graph can be seen to be almost the same as that of the second graph — only 100 concept-links less; however, it is more than 1200 concept-links less than that of the first graph. To recall Chapters 4 and 5, the core members of the Creative Team were brought together for the first cycle, at which time the focal artefact of the team was a strategic plan. In that cycle, team-members were actually in the stage of exploration, looking into the problem domain thoroughly and formulating an overall plan of how to address the problem; so more effort was spent on restructuring the problem domain, which resulted in bigger changes to the concept sets for the documentation. However, the peak-to-peak amplitude should grow less as time goes on because teams tend to exploit existing ideas rather than explore new domains within an overall project framework. This phenomenon can be observed in the second graph, where the peak-to-peak amplitude is approximately half the value of the first graph.

But if we follow this line of argument, the third graph should have shown much less peak-to-peak amplitude compared with the second graph, which is not the case as observed in Figure 6-3. In fact, as the graph demonstrates, Cycle 3 and Cycle 2 have an almost similar rate of peak-to-peak attenuation.

Why did this phenomenon occur? This question led us to re-examine the focal artefact documents, the communications and the interview records.

6.6.3 Change of plans and the addition of an influential concept

Revisiting the process description in section 6.6.1, it was seen that, in fact, the team was not in full exploitation mode as expected. There had been a change of plans — one that caused a minor amount of 'exploration' to occur — and the concept of EEH became the primary catalyst for this change. Initially, the team wanted only to report their results, which had been presented in other venues; the team-members were interested in shaping those results into the report to funders. This is in fact natural to most teams, as reporting results do not require exploration into new domains.

In this case, however, a team-member had introduced a new way of expressing the information in the context of the report by using the EEH concept. Team-members agreed that by making use of this concept, the report would be better presented and thus more appealing to the funders. EEH caused a good deal of excitement amongst team-members, which had encouraged several of them to explore better ways of presenting their results through modifying the presentation of them to better accommodate the concept. In the final version,

four out of six of the Appendices in the report were ‘warped around’ the concept once it had been introduced.

In fact, because of the discovery of this new perspective, the team leader found that the report could be taken to another level. Now, instead of presenting the work completed and including a minor Future Work section to request additional funding — i.e., the marketing section — the marketing segment attained was positioned with more influence in the report. This new perspective had clearly presented the team with an interesting proposition that they could ‘sell’ well.

> We move the goal posts. This has now become both a report of our work that and a marketing exercise. Yes we have done things, but there are more things that could still be done (Team Leader).

As a consequence, the team did not follow the plan or path that they initially thought they would follow. Even though this was the third cycle within an overall project framework, and the team‘s plans and processes were believed to be concretised, we observed that the Creative Team had room to manoeuvre away from the norm. In fact, team-members used plans as a resource rather than as a definitive, unchanging path to achieve their goals. This was very similar to the theory we are about to explore — situated action.

6.7 Cycle Literature Review: Situated Action

In developing her theory of situated action, Suchman (1987) states that, in practice, problems, and the situations in which they are addressed, should each be considered effectively unique. Cooper (2003) agreed with Suchman’s view, and states that a person’s actions are influenced by his/her context and social circumstances, which includes other people.

Further, Suchman explains that plans should be used as a *resource* for action, rather than being seen as *definitive recipes* for action. Under most earlier theoretical frameworks, plans were implicitly viewed as definitive and, in the event of an unexpected outcome, the execution of the plan rather than the plan itself would be questioned. Suchman argues that people developed an almost emotional attachment to plans and would explain away

> wherever possible, actions that violate the structure of an attributed plan {before} the plan itself is reconsidered (Suchman 1987).

In reality, actions people take are normally ‘situated’ in the environment in which they occur; and at times the actions taken emerge from the experience the actors have undergone within

the environment. Suchman argues that therefore the actions of people should not — in practice, cannot — be rigidly predetermined at the beginning of the process: those actions are concretised as the actors progress through the process, moulded by the interactions between the people and their environment. There is a significant difference between real work and representations of real work — i.e., plans.

Blackburn et al. (2007) offer by way of illustration an example of an Australian military team undertaking mission planning. One might expect the planning process of the activity to be well-structured and the team, upon embarking on the planning process, to strictly follow a predetermined path. However, they observe that as time went on the plan

> becomes a guide to remind the participants of the required outcomes and expected state of the plan (Blackburn, Swatman et al. 2007).

The plan, therefore, was in practice emergent: as the team set out on their 'predetermined' path they faced circumstances which would impede their progress unless they altered the plan. This supports Suchman's observations.

What has not been made so clear, however, are the dimensions, extent and scope of effective plan evolution.

6.8 Change of Plans in Cycle 2

Using the context provided by situated action, we examined the previous cycles for evidence of the change of plans. By revisiting the communication and interview records, we discovered that there were indeed certain modifications to the original plan in Cycle 2, the grant development exercise.

To elaborate: we noticed that from stages v2 to v7, researchers had to refocus their efforts on the areas they believed were important at the time — the key measures that the grant assessment panel was looking for. Referring back to the interview data, one of the researchers said that he had studied carefully the key criteria in the grant application guidelines and pointed out to team-members that they should change the approach to increase the chances of acceptance of the application. The focus of the application then began to diverge from the research team's initial expectations, as they placed more emphasis on describing the specific outcomes of the proposed research and less on justifying their research methods through existing background literature. The researchers expanded on the Outcomes section (v2), extending the discussion on the constraints of their research in the form of Scope (v3), and

tying those two explanations together within the Background section (v4). They also described in detail how they would publish the key outcomes of their research (v6). Some less important background material was removed to make room for the additional content (v4 and v7). And as the team moved away from justification of their methods, discussion of some theories (v4) and data capture models were removed (v7).

As well, the team followed an emergent working pattern that was divergent from the initial plan as shown in v11, v12 and v13. In v11, there was a sudden change of subject focus. From the focal artefact data, communication record and subsequent interviews, it was found that creativity had now emerged as a core concept in the grant application document, whereas it had formerly been ranked together with decision support technology and software engineering concepts. According to the researchers, the change was designed primarily to improve the focus of the paper: instead of discussing three different concepts at a time, they wanted to achieve greater impact with just the one concept that (according to them) could make a real difference. The purpose of the grant was to support systems that enhance collaborative thinking, so creativity was chosen as the primary perspective of the team's grant application. Thus the subject of creativity was elaborated upon (v11); and the other two concepts, decision support and software engineering (v13), had less stress placed upon them.

In v14 the realisation arose that the grant assessment panel might need more explicit material regarding the credibility of those carrying out the research, so there was a flurry of email in which each researcher was requested to the team leader a very detailed profile, and did so. After the compilation of the input, that section of the grant application document was extended.

6.9 Conceptual Framework CF3

The conceptual framework that we had at the beginning of this chapter was updated to become CF3. The cycle literature review on the theory of situated action, as well as the comparison between cycles 1, 2 and 3, were used to form CF2. The updated framework is shown in Figure 6-4.

As a result of the analysis of Cycle 3, we added to the conceptual framework the situated action theory on the bottom left corner; for it can be said that the Creative Team made use of plans as a guide, but not as instructions. The findings from this analysis helped us to show that even though exploitation of past results is likely to be the norm for most teams, this is not

always the case: a team can switch to a more exploratory approach if there should arise an impetus to do so.

The Catastrophe Cycle Model expounded the fact that team members do not work in an entirely linear, predictable manner. There is a "plan" driving a team's process, but members do not follow the plan to the letter. There are episodes of opportunism, where team members diverge from their intended goals. In other words, plans are used as a resource as discussed by Suchman in her Situated Action theory. The Catastrophe Cycle Model provides us with a more definitive way to model the process, whereas Suchman's theory gives us leverage to interpret and describe the dynamics of process in detail, as demonstrated in Section 6.8.

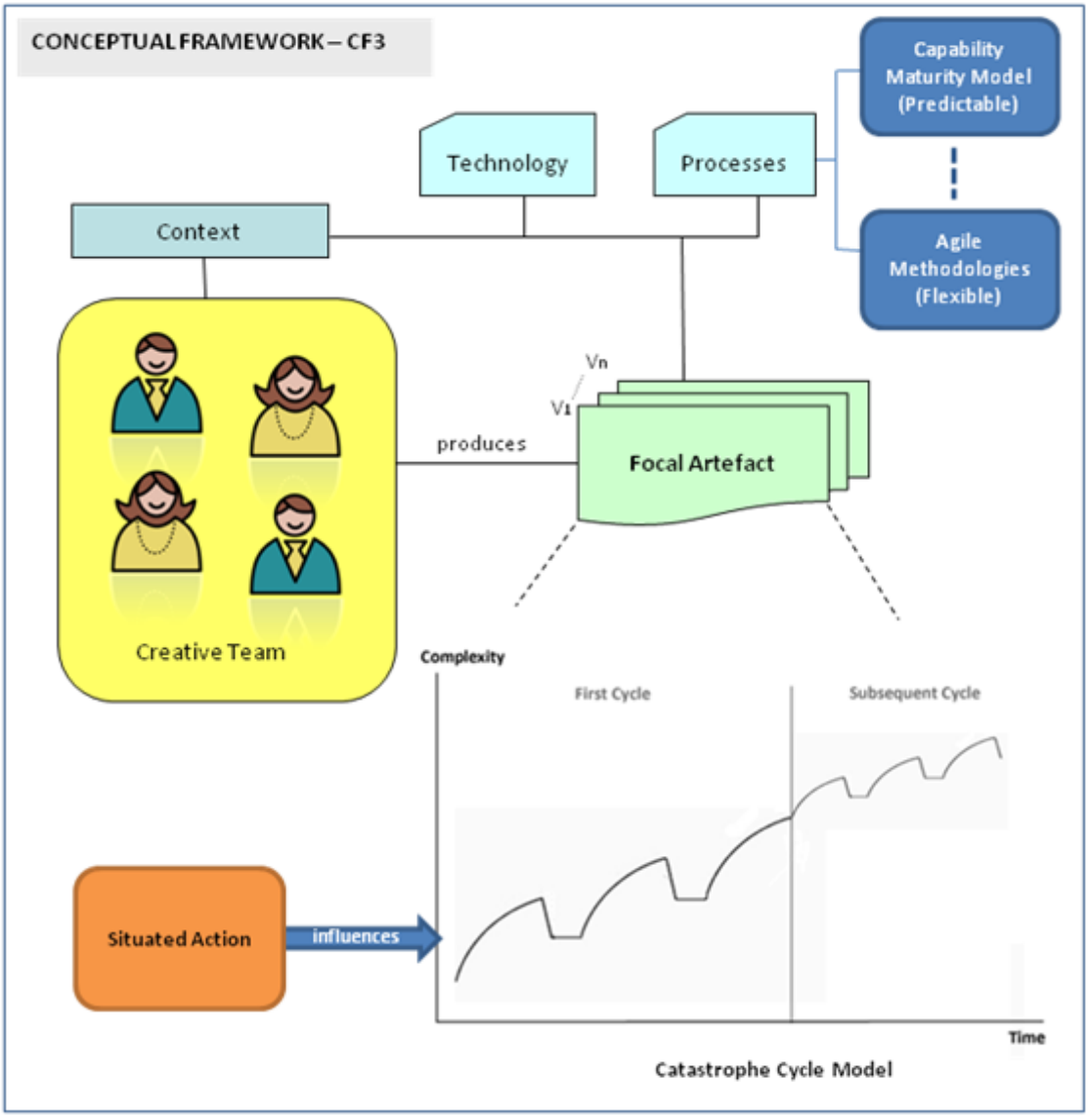


Figure 6-4: Upgraded Conceptual Framework CF3

However, other aspects of the Conceptual Framework remained unchanged. Focal artefact content still dynamically changed in the third cycle and the pattern of this change was comparable with patterns of the first and second cycles. Also, the focal artefact contained the same evolution–revolution–consolidation phases as did its predecessors.

Looking back at the thesis objectives, we addressed both O1 and O2 by observing a project team at work and developing a model of focal artefact progression. With regards to O3, what are the implications and what strategies are needed to support Creative Teams? This theme will be explored in Chapter 7, after we summarise the findings of this thesis.

7 Conclusion

This chapter begins with a summary of the thesis, in order to provide a general recap of the key issues. We then revisit the initial objectives, and how we set out to achieve them. Next, the key findings are discussed and the implications of these findings described at micro level. We take a look at the overall picture, and portray in the Contribution section the wider implications of the thesis and the CreWS project to the community as well as to the nation. Finally, we describe the research constraints, and work that could be conducted in the future; and we illustrate what we think potential ICT support for Creative Teams should look like.

7.1 Thesis summary

Chapter 1 provided an overview of the overarching project of which this thesis forms a part — the CreWS project. We also highlighted the rationale of this project, which sprang from the mediocre level of formal support for Creative Teamwork despite heavy investment in this domain. Lastly, in this chapter were presented the scope and objectives of this thesis.

Chapter 2 described creativity and the current support available to Creative Teams. The chapter ended with a summary of the Catastrophe Cycle Model, which provided a solid grounding for our research.

In Chapter 3, we provided an in-depth discussion on the underlying research methodology of the thesis. It contained the description of how we made use of concepts from both grounded theory and structured methodology to conduct three iterative cycles of studies into Creative Teams at work. An initial conceptual framework was constructed as the foundation, to begin the empirical studies in the following Chapters 4, 5 and 6.

Chapter 4 started with the primary cycle of study into a working Creative Team. The team was involved in designing a strategic plan for research; a focal artefact model was constructed here and interviews conducted with team-members. The findings from this chapter strengthened the Catastrophe Cycle Model as well as concretising the conceptual framework.

Chapter 5 dealt with a subsequent cycle of study of the (very similar) Creative Team, this time working on a grant application — the core composition of the team was unchanged. The grant application had its roots on the first cycle, and the starting point for this second cycle was almost in sync with the ending point of the previous cycle. The findings here not only concretised the Catastrophe Cycle Model, but also provided us with an insight into what the model looked like over a longer period of time — i.e., a 2-cycle period.

In Chapter 6, a final study was carried out on the Creative Team, this time working on a report to funders. The findings solidified CCM even further, taking into account the theory of Situated Action when describing the changes in the CCM.

7.2 Key Findings

To present the key findings effectively, we need first to revisit the objectives of this thesis. Its ultimate goal, as explained in Chapter 1, was to understand team-members as they collaborated asynchronously and in formal places to solve poorly-structured or semi-structured problems.

We expanded the goal in finer detail, and established the following objectives:

1. to understand the process of and communication between Creative Team members while they were solving poorly-structured or semi-structured problems in asynchronous formal place situations;
2. to understand evolutionary and revolutionary processes of focal artefact development and focal artefact dynamics, when a focal artefact is defined as the central object of a creative process, the 'product' that is built by creative team-members;
3. to develop a suitable abstraction or model capable of both representing the above understanding and providing suitable leverage for future ICT intervention strategies.

Certainly, objective 3 was a major concern when first starting the CreWS project; and the development in that area of this thesis found it to be so. It has been explained that we planned not only to observe Creative Teams, but also to generate a concrete model in which future ICT support and intervention could be performed: in short, a new observational approach was to be founded on the basis that future support/intervention would have a reasonable chance of being implemented successfully. We found a model that fitted our purpose exactly — the Catastrophe Cycle Model. This model presented us with a way of structuring the research around the focal artefact: by observing and modelling the dynamics of the focal artefact, we could monitor the progress of a team at any given point of time.

The original Catastrophe Cycle Model as described in Chapter 2 was developed to explain the processes requirements engineers go through when developing a requirements model; however, the model has its limitations in that the focal artefact data collected in that study were post hoc, the data being reconstructed from the recollection of team-members after the project had been completed. This gap was addressed: each item of focal artefact data was

stored in real time once the team had updated it. In a sense, the focal artefact data could be described as ‘ad hoc’ and situated in the real world. Also, the communication trail for the process was stored, and made available.

With a foundational model to draw upon, fulfilling objective 1 and objective 2 became significantly more straightforward. In Chapter 3, we established the research methodology around structured-case: the plan was to establish three structured-case studies (the three cycles of this thesis) into Creative Teams at work. An initial conceptual framework (CF0) that contained the information to that point known and understood was created. The framework was incrementally updated (CF1–CF3) at the end of each cycle. With the research methodology determined, the foundational model on hand and the research objectives in mind, we kick-started the process to observe a professional team at work — the first cycle, in Chapter 4. In this cycle, we found additional evidence that the Catastrophe Cycle Model exists within Creative Teams at work. Also, an additional phase — the consolidation phase — was discovered and explained. Following this, we illustrated a strategy for the observation and modelling of how a Creative Team functions when developing a strategic plan.

Subsequently, the second cycle of study (Chapter 5) was conducted, this time on a Creative Team very similar to the previous one embarking on a grant application project. The findings also hinted at the existence of the evolutionary–consolidating–revolutionary paradigm in the Catastrophe Cycle Model for creative teamwork. In addition, and while comparing the results between this model and its predecessor, we discovered that in a follow-up stage of a project, the peak-to-peak amplitude of the Catastrophe Cycle Model graph was less than that of the initial graph, denoting the fact that the team was exploiting their existing work rather than producing fresh ideas.

We expected the same phenomenon to occur during the third cycle of study (Chapter 6); but, contrary to our expectations, it was not forthcoming. Following the interviews we conducted, we found that a researcher had had a new idea that could propel the project forward, and that the idea has transformed the initial plan. This led us to explain the phenomenon through the lens of situated action theory: plans, in fact, are not constant in an overall project framework, but change from time to time. In this third cycle, the change of plans occurred; importantly, we managed to capture it in our model.

The first part of objective 3, to develop a suitable abstraction of creative teamwork, has resulted in the construction of the conceptual framework; The second part – to provide

suitable platform for future intervention strategies – is important as well. To recap, the ultimate aim of the creative team project is to provide leverage to teams without constraining a team's functions. The creation of intervention strategies is, by itself, a huge task and not within the scope of this thesis. However, we aim to provide concrete ideas on how to extend the work of this thesis. Specifically, in the implication of findings section (Section 7.3), we explain how the complexity graph can be used as a visual indicator to a creative team leader. In the potential ICT support tools section (Section 7.7), we discuss the viablility of having a contingency toolkit that people can use in appropriate situations.

7.3 Implications of Findings

This section was initially presented in the IADIS Multiconference on Computer Science and Information Systems (Tan and Swatman 2009). We established in that paper that ICT support tools are prescriptive and often dictate a generic path that a team needs to follow: therefore, teams' adoption of such tools has not been successful. Results from our case studies clearly showed that teams function, by nature, in a creative and opportunistic manner. Even in the subsequent follow-up of a similar project there was minor restructuring of the problem domain. In her classic work, Suchman (1987) describes how a prescriptive system, rather than assisting a team in achieving its goals, can actually be detrimental.

This is one of the reasons why some of the tools lack impact in general: they fail to cater for the generation of creative insights, those sparks of ideas that team-members have from time to time that deviate from the supposedly normal process. In fact, a classic quote from the CSCW literature suggests that such tools only serve to "automate a fiction" (Ellis & Wainer 1994), as teamwork hardly ever follows a formal flow of actions (Blackburn 2008). Rather than following a rigid set of rules that intrudes on the process and restricts creativity, ICT support for such creative teamwork should be designed to cater for the process *as is*. As well, the team leader should take the role of understanding the underlying creative process, and leverage the effects of insights as they appear.

However, while it is true that teams do not work in a systematic or pre-definable way, our thesis has also shown that the work is not entirely random. Even though we do not specifically define the detailed sub-processes/activities that tend to recur in team activities (being focused on those of this particular Creative Team), we have in fact shown overarching patterns of behaviour within Creative Team processes. The idea of the Catastrophe Cycle

Model, tested and modified in this thesis, showed that there is a rhythm to it and a pathway taken by professional teams when they are involved in creative work. We are convinced, based on the evidence gathered in this research, that developing a rigid, pre-defined and prescriptive process for teams will only be counterproductive because of the opportunistic insights that occur throughout the process. Having said this, we also believe that a viable solution is possible, provided that it is contingent upon the context and flexible. Studies in the future should concentrate on identifying a contingency framework of support that might be concretised into a set of tools, automatically or manually deployable, that will support Creative Team-members. This will be explained further in the Future Work section.

The complexity graph should serve as an informative visual indicator for the team leader. Frequent peaks and falls in the graph during a period of time suggest that there is a rapid restructuring of the problem domain, as team-members are often experiencing new ways of thinking about the problems. In other words, the team is less persistent with regard to existing ideas: they are constantly removed and replaced with fresher ones — this event normally occurs at the earlier stages of a project where the team is trying to solve a poorly-structured problem. Referring back to the first cycle of our results, the peaks and falls were more pronounced during that cycle because the team was still trying to construct the problem domain at that time.

However, the team leader has to take note if there is an excessive frequency of expansion and contraction in the graph during the latter stages of the project, when the deadline is near. A high frequency of changes in the graph at that time suggests that the team may lack understanding of the problem and is too eager to change the core ideas formed at the outset. At this stage, they should focus on solving the problem instead of reformulating key strategies.

In contrast, a period when there is less frequency of expansion and contraction in the complexity graph suggests that the key concepts of the project are already robust. The team is viewing the problem from one perspective, the problem space is more or less determined, and the solution is crystallised. Again, referring back to our results, the second cycle reflected this condition: the team had already comprehended the problem and were set up to solve the problem from the direction that was determined from the first cycle. What they did was to ensure the constant and consistent development of the grant application document, with less restructuring of core concepts, until the document was submitted at the end of the process. If this event were to occur in the earlier stages of a project where creativity is expected to be

rife, it may appear that there is a lack of flexibility within the team in approaching the problem from different angles. When faced with this situation, the team leader has to decide if there is a need to intervene and coax out-of-the-box thinking from his team.

7.4 Contribution

The work of Creative Teams, which our research aims to support, incorporates a significant proportion of semi-structured and/or unstructured knowledge work. Semi-structured and unstructured work like this pervades professional, political and military life and reflects a class of problem which for which little effective support is currently available in the form of leverage without constraining flexibility/creativity. As a consequence our work will be found to contribute in the following areas:

Smart information use. Although it is perhaps more conventional to consider smart information use at the macro level (in application, for example, to an entire organisation, organisational network, or business process), smart use information can have an equally significant impact at the micro level. In a commercial setting, the most significant impact of the smart use of information might be obtained from the leverage given to key teams of professionals (e.g., engineers, software engineers, strategic planners), in a government setting, through the provision of leverage to policymakers, strategists and networks of integrators and in a military setting through leveraging teams of planners, logistics and command and control groups.

Promoting an innovation culture and economy. Deliverables from this research will support innovation in two distinct ways: on the one hand, they will support Creative Teams enabling them to be more effective (leverage without constraining flexibility or creativity); while, on the other they will support the team as it generates creative solutions to problems (creativity with leverage).

The general argument is easy to summarise. In the face of rapid change that is biotechnological (e.g., communications, health), environmental (e.g., global warming, genetically-modified crops), industrial (e.g., offshore manufacturing, globalisation), demographic (e.g., breakdown of the family, ageing of the population), social (e.g., adaptation of immigrants, integration of minorities), and political (e.g., terrorism, achieving fairness in international relations), societies will stagnate and even perish unless there is a dramatic increase in creativity across all fields of endeavour. Thus, creativity can no longer be seen only as the domain of aesthetes and intellectuals concerned with questions of truth and

beauty, as important as these issues may be; but as a pathway to international prosperity and as a means for making the world strong and safe.

The shift away from aesthetics in discussions of creativity has continued, and it has opened up new perspectives on the topic. Adopting a human capital approach (Walberg and Stariha, 1992), writers have given considerable attention to creativity in applied and theoretical sciences (scientific/intellectual creativity), and in management and manufacturing, administration and even the military (survival/prosperity creativity). According to economic theory, ROI in rich countries should have been lower during the second half of the twentieth century than during the first, because the stock of capital was rising faster than the workforce. However, the fact is that ROI was considerably higher. We now see that the decisive factor that defeated the law of diminishing returns was the addition to the system of new knowledge and technology (TETQ, 2002). Ten challenges faced by business in the first decade of the 21st century have been described (Higgins, 1994); these challenges, which include the accelerating rate of change of all facets of business, increasing competition, globalisation and the transformation of First World economies from industrial to knowledge-based economies, act as sources of both problems and opportunities. Higgins proposes that the mechanism that will enable businesses to survive and prosper in this new environment (to solve the problems and utilise the opportunities) is innovation — the process of applying creativity to generate new and valuable ideas, products and processes.

Creativity has been seen as an important aspect in the engineering profession. Burghardt (1995) explains that engineering is, in fact, “a professional life devoted to the creative solution of problems”. Further, Horenstein (2002, p.1) defines engineering as “a career full of discovery, creativity and excitement”. At the level of the individual engineer, creativity is seen as an important component to a successful career (Dekker 1995), which in turn contributes to creativity training becoming more and more popular nowadays (Clapham, 1997, Thackray, 1995). According to a 1995 US Industry Report, the demand for training has exceeded the supply of trainers, despite the fact that corporations are budgeting billions of dollars for creativity training programs (Hequet, 1995).

An innovation culture supports an innovative and innovation-based economy, and is dependent not just upon motivation and reward but, more importantly, on facilitation. The support for Creative Teamwork, particularly in an environment characterised by the explosive growth of ICT, is an area of research that must be addressed as a matter or urgency. As we have argued, there is a dearth of and consequent need for research into support for Creative

Teams that is grounded in data — accurately reflecting the ways in which Creative Teams work (and would like to work) — and where the evaluation of the ICT support provided is also undertaken through the analysis of detailed observational data.

The impact of this research into how to support Creative Teams effectively will be felt in industrial, political and military settings. Our programme of research aims to deliver both short- and medium-term benefits to industry, broadly defined, while establishing a basis for medium- and long-term research, development and, therefore, impact.

7.5 Research Constraints

In this thesis, we developed a model of creative teamwork based on focal artefact dynamics that potentially allowed for ICT intervention and support in the future. In a fashion similar to any other research initiative, there were inevitably a number of constraints affecting the way the research was conducted, as well as the generalisability of the results.

This was an in-depth, interpretive investigation of a Creative Team involved in three interrelated projects: it did not apply to project teams *per se*. However, we have reason to believe that the findings have shown a proof-of-concept and a clear indication on how Creative Teams work, providing a reasonable level of confidence in the generalisability of the results.

The focal artefact investigated in all three projects was in the form of a text corpus. The focal artefact could be in another form in a different project — e.g., a requirements diagram, a physical model, etc. Each class of artefact will have its own approach to metrics collection.

The research was part of a larger research project. While this situation provided the research with a clear direction to move forward; it also constrained the potential of the research from expanding into other domains unstipulated in the larger project requirements; as an example, this research is limited to the asynchronous work of Creative Teams.

There was limited participant availability. When we first started our research, we obtained initial agreement from a number of project teams that would allow us to observe them over the period of the project. Because of privacy concerns (we indeed needed to be privy to sensitive business documents) and timing issues (project teams being busy with tasks involved in ensuring their projects ran smoothly, preventing their

scheduling time for interviews with us, e.g.), some were not able to follow the commitment.

Lastly, project resources were finite. Although the larger research project was funded, the funds were distributed over a number of project areas. Without employing external assistance, we were required to manually generate Leximancer reports for each version of the artefact, compile the focal artefact metrics filtering the communication records; all these on top of performing the actual observation and analysis of the data. If resources were made available for looking after this manual work, we are confident that we could observe multiple project teams in the event of their availability.

7.6 Future Work

This three-cycle research can serve as a solid platform for future research on Creative Teams. The focus of future work could be on:

- Conducting further structured-case studies on the same Creative Team when it embarks on another 'continuation' project. Additional case studies that would be beneficial include examining the exploration–exploitation paradigm further within the context of the Catastrophe Cycle Model to provide us with a handle on the events that unfold within a Creative Team that has been collaborating over an extended period of time.
- Conducting further cycles of study on Creative Teams in the industrial world. These teams could be involved in work of a different nature — software engineering, military command and control and/or design, for example. By expanding the research focus, we would be able to extend this proof-of-concept study through further data collection and analysis.
- Employing alternative research strategies; e.g., from exploration to theory-testing strategies. Although the structured-case methodology provided us with a solid grasp of the model of Creative Teamwork, we believe that it is now time to delve into more orthodox, scientific research methods that study multiple teams simultaneously. These research methods could provide researchers with a way to generate statistically sound, subjective results. However, caution should be maintained; as large-scale, scientifically testable experiments could potentially disturb the normal behaviour of a team. Capturing people's perceptions of what they do rather than what they have actually done remains an issue with regard to such experiments: on the one hand, an

interpretive–explorative type of research methodology provides us the rich picture of happenings on the ground; on the other hand, scientific research methods provide us with the means to capture significantly larger data streams.

- Extending CF3 to accommodate synchronous work domain. From the experience and insights obtained from this research we found that, in practice, primarily observing asynchronous activity provides us with a wide picture of what happens in a project. However, to achieve a view of the minutiae the approach should be merged with the observation of synchronous activity within face-to-face meetings. It would be arguable, if one should embark on another project, at this stage to ethnographically study synchronous activities.
- Finding a method to automatically categorise group messages (e.g., email), event sources and changes in the group database. By employing the help of a concept mining software like Leximancer, we should be able to create and evolve an ontology that represents a Creative Team's activities. With this, we could integrate the ontology into the Catastrophe Cycle Model diagram and provide a rich picture of the occurrences inside the team at any given time and, consequently enable effective ICT support.
- Identifying potential ICT support tools for situations described as part of the model. We believe that ICT Support is most likely to be effective if the team is provided with the flexibility to respond to various types of situations. A possible scenario would be the creation of an adaptable toolbox with a variety of tools that could be used by team-members to respond to different problem situations and different team environments. The toolbox-based approach will be detailed in the following section.

7.7 Potential ICT support tools: a reflection

What are the potential support tools for the situations described by the framework?

Due to the opportunistic nature of creative teamwork, any design of computer tools must support the creative process. Firstly, as a prerequisite to managing the process it is imperative to have a flexible system that will allow alteration of the process model as necessary, as well as a tool to record the rationale behind changes. Further, due to the constant restructuring of the problem domain, there is a need to support the development process as it really is — a contingency-based support strategy or, in other words, a toolbox-based approach to supporting the process. In the approach written of in this thesis, team-members had access to

a ‘tool repertoire’; and they decided how to apply these tools to complement their work processes (Nutt 1996).

The relevant tools that are available in the toolbox would differ from project to project. We illustrate the potential support tools for specific situations by drawing them from a collaborative authoring project described in our Methodology and Results section; two examples are provided, both from the second cycle of the project — one during a downward slope in the complexity graph and the other during an upward slope.

From Chapter 5’s activities came this vignette of what occurred when there was a downwards slope in the complexity graph:

> In version 7, a great deal of content, specifically the description of different Software Engineering models was removed from the Methodology section of the application. Paragraphs describing the capture of various types of data - social interaction, artefact development, technology-mediated interaction - were also removed. From the interviews, it emerged that the researchers drew from their existing knowledge when writing the first version of this grant application. Some elements of this knowledge could be found in the strategic plan. Therefore, they began by stating their existing ideas then (in this revision) adjusted the ideas once the vision became clear. In this version, they had to prune the concepts to keep the application focussed. In doing so, they believed that a lot of unneeded "noise" was removed from the presentation.

It is apparent that during a downward slope team-members work to consolidate core ideas and remove redundant concepts.

During a subsequent interview with one of the team it was suggested that a concept mapping tool such as Mindjet's Mindmanager 8 (www.mindjet.com) would assist the team at a time such as that described: they needed a document map to display all the key ideas available within it so that they could then merge similar ideas. The use of the tool was discussed by team members and placed in the “future implementations” folder, to be considered when the team works on similar projects.

Here is a vignette showing what happened when there was an upward slope in the complexity graph:

> Considerable content was added in v6. The researchers added key strategies on how the results of the study would be presented and diffused (Communication of

> Results section) and some extensions were made to the description of research team personnel. (Chapter 5)

During this period, team-members were adding ideas/concepts to the document and a brainstorming tool would be useful to them in this situation. With this tool acting as a focal point, team-members could store their generated ideas as well as comment on each others' ideas.

The research team under observation undertook a working process that followed an evolutionary path towards achieving its goals, and yet at times that path was interspersed with periods of opportunistic behaviour. The main contribution of this paper is to explain the implications of this observation and present an approach in which this creative process could be effectively supported.

The complexity graph, our suggested model for a creative team process, has also been discussed at length. Recurrent peaks and falls in the graph indicate that there is a frequent restructuring of the problem domain. However, a lack of changes to the graph suggests that the problem domain is solidified and the team is not thinking out of the box. Because of the opportunistic nature of collaborative work, we strongly believe that instead of being prescriptive, effective ICT support needs to adapt to the process undertaken by teams.

The way forward for Creative Teams is to support them with a contingency toolbox that contains a selection of sets of tools that will allow them to respond appropriately to different types of situations in a dynamic project environment.

7.8 Conclusion

> Success is a journey, not a destination. The doing is often more important than the outcome (Arthur Ashe).

This research started with the primary goal of observing a Creative Team at work in the asynchronous, formal place domain.

The conceptual framework generated through this research and presented at its end not only strengthens the Catastrophe Cycle Model but also provides a proof of concept that can be used in further research work carried out by Creative Teams, as well as forming a bedrock for ICT intervention strategies in the future.

We believe that this research has contributed significantly to domains that are involved in providing ICT-based support for groups such as CSCW and CIT research.

8 References

Ackerman, MS 2000, "The intellectual challenge of CSCW: the gap between social requirements and technical feasibility"; *Human-Computer Interaction,* vol. 15, no. 2 & 3, pp. 179-203.

Ahonen, M & Murto, H 2004, "Building a digital portfolio that supports informal learning, creativity and mobility — a design science viewpoint"; *Proceedings of the Eportfolio Conference,* La Rochelle, France, p. 263.

Akin, Ö & Akin, C 1996, "Expertise and creativity in architectural design", *Proceedings of the First International Symposium on Descriptive Models of Design,* Taskisla, Istanbul, Turkey, pp. 1-5.

Amabile, T 1989, *Growing up Creative: Nurturing a Lifetime of Creativity,* Crown House Publishing Ltd., Norwalk, USA.

Amabile, T 1996, *Creativity in Context,* Westview Press Inc., Boulder, USA.

Anderson, A, McEwan, R, Bal, J & Carletta, J 2007, "Virtual team meetings: an analysis of communication and context", *Computers in Human Behaviour,* vol. 23, no. 5, pp. 2558-2580.

Arnott, D & Pervan, G 2005, "A critical analysis of decision support systems research", *Journal of Information Technology,* vol. 20, no. 2, pp. 67-87.

Audia, PG & Goncalo, JA 2007, "Past success and creativity over time: a study of inventors in the hard disk drive industry", *Management Science,* vol. 53, no. 1, p. 1.

Bach, J 1994, "The immaturity of the CMM"; *American Programmer,* vol. 7, no. 9, pp. 13-18.

Bamberger, J 1997, "Essence of the Capability Maturity Model"; *Computer,* vol. 30, no. 6, pp. 112-114.

Bangert-Drowns, RL 1993, "The word processor as an instructional tool: A meta-analysis of word processing in writing instruction"; *Review of Educational Research,* vol. 63, no. 1, p. 69.

Bannon, L & Schmidt, K 1991, "CSCW: four characters in search of a context", in *Studies in computer-supported cooperative work: theory, practice and design,* eds. JM Bowers & SD Benford, North-Holland Publishing Co., pp. 3-16.

Bannon, L 1997, “Group Decision Support Systems: an analysis and critique”, *Proceedings of the European Conference on Information Systems,* Cork, Ireland, June 1997, pp. 526-539.

Bardram, J 1997, “I love the system - I just don't use it!”; *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work,* Phoenix, Arizona, USA, , pp. 251-260.

Basadur, M 2005, “Management: synchronizing different kinds of creativity”, in *Creativity across domains: Faces of the muse,* eds. JC Kaufman & J Baer, Lawrence Erlbaum Associates, Hillsdale, New Jersey, pp. 261-279.

Begole, JB, Tang, J, Smith, R & Yankelovich, N 2002, “Work rhythms: analyzing visualizations of awareness histories of distributed groups”, *Proceedings of the 2002 ACM conference on Computer-Supported Cooperative Work,* New Orleans, pp. 334-343.

Benbasat, I, Goldstein, DK & Mead, M 1987, “The case research strategy in studies of information systems, *MIS Quarterly,* vol. 5, pp. 369-386.

Benbasat, I. 1984. “An analysis of research methodologies”, in *The information systems research challenge,* ed. FW McFarlan, Harvard Business School Press, Boston, Massachusetts, pp. 47-85.

Bentley, R, Hughes, J, Randall, D, Rodden, T, Sawyer, P, Shapiro, D & Sommerville, I 1992, “Ethnographically-informed systems design for air traffic control”, *Computer Supported Cooperative Work,* pp. 123-129.

Bharati, P & Chaudhury, A 2004, “An empirical investigation of decision-making satisfaction in Web-based decision support systems”, *Decision Support Systems,* vol. 37, no. 2, pp. 187-197.

Bhargava, HK, Power, DJ & Sun, D 2007, “Progress in web-based decision support technologies”, *Decision Support Systems,* vol. 43, no. 4, pp. 1083-1095.

Blackburn, T 2008, “A framework for understanding and supporting human actions in small team interactions”, *PhD Thesis,* School of Computer and Information Science, University of South Australia, Australia.

Blackburn, T, Swatman, P & Vernik R 2007. “Cognitive dust: a framework that builds from CSCW concepts to provide situated support for small group work”; *Lecture Notes in Computer Science,* vol. 4402, pp. 1-12.

Blanchard, K, Randolph, A & Grazier, P 2007, *Go team!: take your team to the next level*, Berrett-Koehler Publishing Inc., San Francisco, USA.

Boehm, B 2002, “Get ready for agile methods, with care”; *Computer,* vol. 35, no. 1, pp. 64-69.

Boland, R 1985, “Phenomenology: a preferred approach to research in information systems”, in *Research Methods in Information Systems,* eds. E Mumford, R Hirschheim, G Fitzgerald & T Wood-Harper, NorthHolland, Amsterdam, pp. 193-201.

Bourner, T 1996, “The research process: four steps to success”, in *Research methods: guidance for postgraduates,* ed. Greenfield, T, Arnold, London.

Bowers, J 1994, “The work to make a network work: studying CSCW in action”, *Proceedings of the 1994 ACM Conference on Computer-Supported Cooperative Work,* Chapel Hill, North Carolina, United States, pp. 287-298.

Braa, J. 1995 “Decentralization, primary health care and information technology in developing countries: case studies from Mongolia and South Africa” in *Information technology and socio-economic development: opportunities and challenges,* ed, M Odedra, Ivy League Publishing, pp. 130-142.

Burghardt, M 1995. *Introduction to the engineering profession,* Addison Wesley, New York.

Candy, L & Hori, K 2003, “The digital muse: HCI in support of creativity”, *Interactions,* vol. 10, no. 4, pp. 44-54.

Candy, PC 1991, *Self direction for lifelong learning: a comprehensive guide to theory and practice.* Jossey Bass, San Francisco.

Carson, D, Gilmore, A, Perry, C & Gronhaug, K 2001, *Qualitative marketing research,* Sage, London, 2001.

Carroll & Swatman 2000, “Structured-case: a methodological framework for building theory in information systems research”, *European Journal of Information Systems,* vol. 9, no. 4, pp. 235-242.

Checkland, P 1981, *Systems thinking, systems practice,* John Wiley & Sons Ltd, Chichester.

Checkland, P & Holwell, S 1988, *Information, systems and information systems: making sense of the field,* John Wiley & Sons Ltd, Chichester.

Chua, WF 1986, “Radical developments in accounting thought”, *The Accounting Review,* vol. 61, pp. 601–632.

Clarke, R 2001, “If e-Business is different then so is research in e-Business”, *IFIP TC8 Working Conference on E-Commerce/E-Business,* Salzburg.

Christiansen, E. (1996). “Tamed by a rose: computers as tools in human activity”, in *Context and Consciousness,* ed. B Nardi, MIT Press, pp. 175-198.

Clapham, M 1997 “Ideational skills training: a key element in creativity training programs”, *Creativity Research,* vol. 10, pp. 33-44.

Cockburn, A & Highsmith, J 2001, “Agile software development: the people factor”; *Computer,* vol. 34, no. 11, pp. 131-133.

Collins, M & Amabile, T 1999, “Motivation and creativity”, in *Handbook of creativity,* ed. R Sternbeck, Cambridge University Press, pp. 297-312.

Cooper, M 2003, *Situated action,* viewed 30 May 2005, <http://ella.slis.indiana.edu/~micooper/L642/SituatedAction.htm>

Coyne, R 2005, “Wicked problems revisited”, Design Studies, vol. 26, no. 1, pp. 5-17.

Crabtree, A, Rodden, T & Benford, S 2005, “Moving with the times: IT research and the boundaries of CSCW”, *Computer-Supported Cooperative Work,* vol. 14, no. 3, pp. 217-251.

Cropley, D & Cropley, A 2005, “Engineering creativity: A systems concept of functional creativity”, in *Creativity across domains: faces of the muse,* eds. J Kaufman & J Baer, Lawrence Erlbaum Associates Inc, New Jersey, pp. 169-185.

Csikszentmihalyi, M 1991, *Flow: the psychology of optimal experience,* Harper-Perennial, New York.

Csikszentmihalyi, M 1996, *Creativity: flow and the psychology of discovery and invention*, Harper-Collins, New York.

Csikszentmihalyi, M 1999, "Implications of systems perspective for the study of creativity", in *Handbook of creativity*, ed. R Sternbeck, Cambridge University Press, pp. 331-338.

Csikszentmihalyi, M, Abuhamdeh, S, & Nakamura, J. 2005. "Flow", *Handbook of Competence and Motivation*, ed. A Elliot, The Guilford Press, New York, pp. 598-608.Danesh, MR & Jin, Y 1999, "ADN: An agent-based decision network for concurrent design and manufacturing"; *Proceedings of the 1999 ASME Design Engineering Technical Conferences*, Las Vegas, Nevada, pp. 1-11.

Davies, I, Green, P, Rosemann, M, Indulska, M & Gallo, S 2006, "How do practitioners use conceptual modeling in practice?", *Data & Knowledge Engineering*, vol. 58, no. 3, pp. 358-380.

de Vreede, GJ, Vogel, D, Kolfschoten, G & Wien, J 2003, "Fifteen years of GSS in the field: a comparison across time and national boundaries"; *Proceedings of the 36th Annual Hawaii International Conference on System Sciences.*

Dekker, D 1995 "Engineering design processes, problem solving and creativity", *International Association for Engineering Education Frontiers in Education Conference*, pp. 16-19.

Deokar, A & Madhusudan, T 2005, "Developing Group Decision Support Systems for deception detection", *Proceedings of the 38th Annual Hawaii International Conference on System Sciences*, p.24.

DeSanctis, G & Gallupe, B 1984, "Group decision support systems: a new frontier", *SIGMIS Database*, vol. 16, no. 2, pp. 3-10.

Dick, B 1999, *What is action research?*, viewed 25 November 2009, <http://www.scu.edu.au/schools/gcm/ar/whatisar.html>

Ducheneaut, N, Yee, N, Nickell, E & Moore, RJ 2006, "Alone together?': Exploring the social dynamics of massively multiplayer online games", *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 407-416.

Dustdar, S, Hoffmann, T & van der Aalst, W 2005, "Mining of ad-hoc business processes with TeamLog", *Data & Knowledge Engineering*, vol. 55, no. 2, pp. 129-158.

Elam, JJ & Mead, M 1990, "Can software influence creativity?" *Information Systems Research,* vol. 1, no. 1, pp. 1-22.

Engestrom, Y. (1993). Developmental Studies of work as a testbench of activity theory: the case of primary care medical practice, in Understanding Practice, eds. S Chaiklin & J Lave. Cambridge University Press, Cambridge.

Farooq, U, Carroll, J, M. & Ganoe, C, H. 2005, "Supporting creativity in distributed scientific communities"; *Proceeding of the 2005 International ACM SIGGROUP conference on Supporting Group Work,* Sanibel Island, Florida, USA, pp. 217-226.

Feurer, R, Chaharbaghi, K & Wargin, J 1996, "Developing creative teams for operational excellence", *International Journal of Operations & Production Management,* vol. 16, no. 1, pp. 5-18

Fillipi, G & Theureau, J 1993, "Analyzing cooperative work in an urban traffic control room for the design of a coordination support system", *Proceedings of the 3rd Conference on Computer Supported Cooperative Work,* pp. 171-186.

Fischer, G 2000, "Symmetry of ignorance, social creativity, and meta-design", *Knowledge-based Systems,* vol. 13, no. 7-8, pp. 527-537.

Fjeld, M, Bichsel, M, Voorhorst, F, Lauche, K, Krueger, H & Rauterberg, M 1999, "Designing graspable groupware for co-located planning and configuration tasks", *EACE Quarterly,* vol. 3, no. 2, pp. 16-21.

Fjermestad, J & Hiltz, SR 1999, "An assessment of Group Support Systems experimental research: methodology and results", *Journal of Management Information Systems,* vol. 15, no. 3, pp. 7-149.

Fjermestad, J 2004, "An analysis of communication mode in group support systems research"; *Decision Support Systems,* vol. 37, no. 2, pp. 239-263.

Flower, L & Hayes, JR 1981, "A cognitive process theory of writing", *College Composition and Communication,* vol. 32, no. 4, pp. 365-387.

Ford, K, Petry, F, Adams-Webber, J & Chang, P 1991, "An approach to knowledge acquisition based on the structure of personal construct systems", *IEEE Transactions on Knowledge and Data Engineering,* vol. 3, no. 1, pp. 78-88.

Frankfort-Nachmias, C & Nachmias, D 1996, *Research methods in the social sciences, 5th edn,* St. Martin's Press, New York.

Galliers, R 1992, "Choosing information systems research approaches", in *Information systems research: issues, methods and practical guidelines,* ed. R Galliers, Blackwell Scientific, Oxford,

Galliers, R & Land, F 1987, "Choosing appropriate information systems research methodologies", *Communication of the ACM,* vol.30, pp. 900-902.

Garrick, J 1999, "Doubting the philosophical assumptions of interpretive research." *Qualitative Studies in Education,* vol. 12, no. 2, pp. 147-156.

Gilsing, V & Nooteboom, B 2006, "Exploration and exploitation in innovation systems: The case of pharmaceutical biotechnology"; *Research Policy,* vol. 35, no. 1, pp. 1-23.

Glaser, BG & Strauss, AL 1967, *The discovery of grounded theory: strategies for qualitative research,* Weidenfeld and Nicolson, London.

Glaser, BG 1992, *Basics of grounded theory analysis,* Sociology Press, Mill Valley, CA.

Goldenberg, J, Mazursky, D & Solomon, S 1999, "Creative sparks", *Science,* vol. 285, no. 5433, September 3, 1999, pp. 1495-1496.

Goles, T & Hirschheim RA 2000, "The paradigm is dead, the paradigm is dead...long live the paradigm: the legacy of Burrell and Morgan", *Omega,* vol. 28, no. 3, pp. 249-268.

Goulding, C 1999 "Consumer research, interpretive paradigms and methodological ambiguities", *European Journal of Marketing,* vol. 33, no. 9/10, pp. 859-873.

Grech, MR, Horberry, T & Smith, A 2002, "Human error in maritime operations: analyses of accident reports using the Leximancer tool", *Proceedings of the Human Factors and Ergonomics Society 46th Annual Meeting,* Baltimore, MD.

Greif, I 1988, *Computer Supported Cooperative Work: a book of readings,* Morgan Kaufman Publishers, Inc., San Mateo, California.

Grudin, J 1988, “Why CSCW applications fail: problems in the design and evaluation of organisation of organisational interfaces”, *Proceedings of the 1988 ACM Conference on Computer-Supported Cooperative Work,* Portland, Oregon, United States.

Guba, EG & Lincoln, YS 1994. “Competing paradigms in qualitative research”, *Handbook of qualitative research,* eds. NK Denzin & YS Lincoln, Sage Publications, Thousand Oaks, CA, pp. 105-117.

Hargadon, A & Sutton, R 1997, “Technology brokering and innovation in a product development firm”, *Administrative Science Quarterly,* vol. 42, pp. 716-749.

Harris, M, Hevner, AR & Collins, RW 2006, “Controls in flexible software development”; *Proceedings of the 39th Annual Hawaii International Conference on System Sciences,* vol. 9, pp. 1-10.

Hayes, JR 1989, “Cognitive processes in creativity”, in *Handbook of creativity,* eds. JA Glover, RR Ronning & CR Reynolds, Plenum Press, New York, pp. 135-145.

Heath H & Cowley S 2004, “Developing a grounded theory approach: a comparison of Glaser and Strauss”, *International Journal of Nursing Studies*, vol. 41, no. 2, pp. 141-150.

Hequet, M 1995 “Doing more with less”, *Training,* pp. 76-82.

Hewett, TT, Baecker, R, Card, S, Carey, L, Gasen, J, Mantei, M, Perlman, G, et al. 1996, *ACM SIGCHI Curricula for Human-Computer-Interaction*, viewed 26 November 2007 <http://sighi.org/cdg/cdg2.html>

Higgins, J 2002. *101 creative problem solving techniques - the handbook of new ideas for business, eDesign concepts for engineers,* Prentice Hall Inc, Upper Saddle River, NJ.

Highsmith, J & Cockburn, A 2001, “Agile software development: the business of innovation”; *Computer,* vol. 34, no. 9, pp. 120-122.

Hill, R & Begole, JB 2003, “Activity rhythm detection and modeling”; *CHI 2003, Conference on Human Factors in Computing Systems,* Ft. Lauderdale, FL, USA, pp. 782-783.

Hirschheim, RA 1992, “Information systems epistemology: a historical perspective in information systems research”, in Issues, *Methods and Practical Guidelines,* eds R Galliers, Blackwell Scientific Publications, Oxford, pp. 28-60,

Hirschheim, RA & Klein, HK 1989, "Four paradigms of information systems development." *Communications of the ACM,* vol. 32, no. 10, pp. 1199-1216.

Hoffmann, O, Cropley, D, Cropley, A, Nguyen, L & Swatman, P 2005, "Creativity, requirements and perspective", *Australasian Journal of Information Systems,* vol. 13, no. 1, pp. 159-175.

Horenstein, MN 2002. *Design concepts for engineers,* Prentice Hall, Upper Saddle River, NJ, USA.

Hughes, J, King, V, Rodden, T & Andersen, H 1994, "Moving out from the control room: ethnography in system design"; *Proceedings of the 1994 ACM Conference on Computer-supported Cooperative Work,* pp. 429 - 439.

Hughes, J, Randall, D & Shapiro, D 1992, "Faltering from ethnography to design", *Proceedings of the 1992 ACM conference on Computer-Supported Cooperative Work,* Toronto, Canada, pp. 115-122.

Kaplan, B & Duchon D 1988, "Combining qualitative and quantitative methods in information systems research: a case study", *MIS Quarterly,* vol. 12, no. 4, pp. 571-587.

Kaplan, B & Maxwell JA 1994, "Qualitative research methods for evaluating computer information systems, in *Evaluating health care information systems: methods and applications,* eds. JG Anderson, CE Aydin, and SJ Jay, Sage, Thousand Oaks, CA, pp. 45-68.

Kaplan, SM, Fitzpatrick, G, Mansfield, T & Tolone, WJ 1997, "MUDdling through [collaborative systems]", *Proceedings of the Thirtieth Hawaii International Conference on System Sciences,* pp. 539-549.

Kaptelinin, V & Nardi BA 1997, "Activity Theory: Basic Concepts and Applications", *Tutorial for CHI97.* Atlanta.

Kaufman, J & Baer, J 2005, *Creativity across domains: faces of the muse,* L. Erlbaum Associates, Mahwah, N.J.

Kellogg, RT 1987, "Effects of topic knowledge on the allocation of processing time and cognitive effort to writing processes"; *Memory and Cognition,* vol. 15, no. 3, pp. 256-266.

Klein, HK & Hirschheim, R 1994, "The application of neohumanist principles in information systems", *Development, in human, organizational, and social dimensions of information systems development,* eds. Avison D, Kendall, JE & DeGross, JI, pp. 263-280, NorthHolland, Amsterdam.

Klein, HK & Myers, MD 1999, "A set of principles for conducting and evaluating interpretive field studies in information systems", MIS Quarterly, vol. 23, no. 1, pp. 67-94.

Kock, N 2004, "The three threats of action research: a discussion of methodological antidotes in the context ofan information systems study" *Decision Support Systems,* vol. 37, no. 2, pp. 265-286.

Kotler, P, Adam, S, Brown, L & Armstrong, G 2006, *Principles of Marketing, 3rd edn,* Prentice Hall Inc.

Kraemer, K, L. & King, JL 1988, "Computer-based systems for cooperative work and group decision making", *ACM Computing Surveys,* vol. 20, no. 2, pp. 115-146.

Lauche, K 2005, "Collaboration among designers: analysing an activity for system development", *Computer-Supported Cooperative Work,* vol. 14, no. 3, pp. 253-282.

Lawson, B 1997, *How designers think: the design process demystified,* Butterworth Architectural Press,

Lee, J, Lee, J & Lee, H 2003, "Exploration and exploitation in the presence of network externalities"; *Management Science,* vol. 49, no. 4, pp. 553-570.

Lee, TW 1999, *Using qualitative methods in organizational research,* Sage, Thousand Oaks, CA.

Leontiev, A 1978, *Activity, Consciousness and Personality,* Prentice Hall, Englewood Cliffs, NJ.

Lewis, LF, Bajwa, D & Pervan, G 2004, "An empirical assessment of the assimilation patterns and the benefits of collaborative information technologies", *Journal of Computer Information Systems,* pp. 16-26.

Leximancer 2008, *Leximancer Concept Miner,* viewed 10 November 2008, <https://www.leximancer.com/site-media/lm/science/leximancer-concept-miner.pdf>

Lin, L, Geng, X & Whinston, AB 2005, "A sender-receiver framework for knowledge transfer", *MIS Quarterly,* vol. 29, no. 2, pp. 197-219.

Lu, N 2006. "Enhancing the effectiveness of information access and consumption for organic farmers in rural areas using mobile commerce", *PhD Thesis,* School of Computer and Information Science, University of South Australia, Australia.

Lubart, TI 2001, "Models of the creative process: past, present and future", *Creativity Research Journal,* vol. 13, no. 3&4, pp. 295-308.

Luff, P, Heath, C & Greatbatch, D 1992, "Tasks-in-interaction: paper and screen based documentation in collaborative activity", *Proceedings of the 1992 ACM conference on Computer-supported cooperative work,* pp. 163 - 170.

Mandviwalla, M & Gray, P 1998, "Is IS research on GSS relevant?", *Information Resources Management Journal,* vol. 11, no. 1, pp. 29-37.

March, JG 1991, "Exploration and exploitation in organisational learning*", Organisation Science,* vol. 2, no. 1, pp. 71-87.

Martin, PY & Turner, BA 1986, "Grounded theory in organisational research", *The Journal of Applied Behavioural Science,* vol. 22, no. 2, pp. 141-157.

Marzano, G & Scott, N 2006, "Consistency in destination branding: the impact of events", *Global Event Congress,* Brisbane, Australia, pp. 196-206.

Masoodian, M, Apperley, M & Frederickson, L 1995, "Video support for shared work-space interaction: an empirical study", *Interacting with Computers,* vol. 7, no. 3, pp. 237-253.

Mayer, R 1999, "Fifty years of Cceativity Research", in *Handbook of creativity,* ed. R Sternbeck, Cambridge University Press, pp. 449-460.

McGhee, G, Marland, G & Atkinson, J 2007, "Grounded theory research: literature reviewing and reflexivity", *Journal of Advanced Nursing,* vol. 60, no. 3, pp. 334-342.

Muller, MJ , Geyer, W, Brownholtz, B, Wilcox, E & Millen, DR 2004, "One-hundred days in an activity-centric collaboration environment based on shared objects", *Proceedings of the SIGCHI conference on Human factors in computing systems,* pp. 375-382.

Myers, MD 1997, "Qualitative Research in Information Systems", *MIS Quarterly,* vol. 21, no. 2, pp. 241-242.

Myers, MD 2002, "Qualitative Research in Information Systems, *MISQ*, viewed 27 October 2006, <http://www.qual.auckland.ac.nz>

Myers, MD & Avison, DE 2002, *Qualitative research in information systems: a reader*, Sage Publications, London.

Nakamura, LI 2000, "Economics and the new economy: the invisible hand meets creative destruction", *Business Review of Philadelphia Federal Reserve Bank,* pp. 15-30.

Nardi, B. 1996, "Studying context: a comparison of activity theory, situated action models and distributed cognition". *Context and Consciousness; Activity Theory and Human Computer Interaction*, Massachussetts, pp. 66-102.

Neale, DC, Carroll, JM & Rosson, MB 2004, "Evaluating computer-supported cooperative work: models and frameworks", *Proceedings of the 2004 ACM Conference on Computer-Supported Cooperative Work*, pp. 112-121.

Neuman, WL 2003, *Social research methods: qualitative and quantitative approaches*, Allyn and Bacon, Boston.

Neuman, WL 2004, *Basics of social research: quantitative and qualitative methods*, Allyn and Bacon, Boston.

Ng-Kruelle, SH 2006 "The price of convenience: implications of socially pervasive computing for personal privacy", *PhD Thesis,* School of Computer and Information Science, University of South Australia, Australia.

Nguyen, L 2000, "Incorporating design explanation within Formal Object-Oriented Method", *PhD Thesis,* Deakin University, Australia.

Nguyen, L & Swatman, P 2003, "Managing the requirements engineering process", *Requirements Engineering*, vol. 8, no. 1, pp. 55-68.

Nguyen, L, Swatman, P & Shanks, G 1999, "Using design explanation within formal object oriented method", *Requirements Engineering*, vol. 4, no. 2, pp. 152-164.

Noel, S & Robert, J-M 2004, "Empirical study on collaborative writing: what do co-authors do, use, and like?", *Computer-Supported Cooperative Work*, vol. 13, no. 1, pp. 63-89.

Nunamaker, J, Briggs, R, Mittleman, D, Vogel, D & Balthazard, P 1997, "Lessons from a dozen years of group support systems research: A discussion of lab and field findings", *Journal of Management Information Systems,* vol. 13, pp. 163-207.

Nutt, GJ 1996 "The evolution towards flexible workflow systems", *Distributed Systems Engineering,* vol. 3, pp. 276-294.

Orlikowski, WJ 1993, "CASE tools as organisational change : investigating incremental and radical changes in systems development", *MIS Quarterly,* vol. 17, no. 3, pp. 309-340.

Orlikowski, WJ & Baroudi JJ 1991, "Studying information technology in organizations: research approaches and assumptions", *Information Systems Research,* vol. 2, pp. 1-28.

Patton, MQ 1990, *Qualitative evaluation and research methods*, Sage Publications, Newbury Park, California.

Paulk, MC 2002, "Agile methodologies and process discipline", *Crosstalk,* pp. 15-18.

Penichet, VMR, Marin, I, Gallud, JA, Lozano, MD & Tesoriero, R 2007, "A classification method for CSCW systems", *Electronic Notes in Theoretical Computer Science,* vol. 168, pp. 237-247.

Pettersson, M, Randall, D & Helgeson, B 2002, "Critical cases: Ambiguities, awareness and economy: a study of emergency service work", *Computer-Supported Cooperative Work,* vol. 13, no. 2, pp. 125-154.

Pettigrew, AM 1990, "Longitudinal field research on change: theory and practice", *Organisation Science,* vol. 1, no. 3, pp. 267-292.

Poston, R 2005, "Effective use of knowledge management systems: a process model of content ratings and credibility indicators", *MIS Quarterly,* vol. 29, no. 1, p. 10.

Pycock, J & Bowers, J 1996, "Getting others to get it right: an ethnography of design work in the fashion industry", *Proceedings of the 1996 ACM conference on Computer-supported Cooperative Work,* pp. 219-228.

Qureshi, S, Liu, M & Vogel D 2005, "A grounded theory analysis of e-collaboration effects for distributed project management", *Proceedings of the 38th Hawaii International Conference on System Sciences,* p.264c.

Raden, R 2005, *Shedding light on shadow it: is Excel running your business?*, viewed 20 May 2009. <http://DSSResources.com>

Rains, SA 2005, "Leveling the organisational playing field—virtually: a meta-analysis of experimental research assessing the impact of Group Support System use on member influence behaviors", *Communication Research*, vol. 32, no. 2, pp. 193-234.

Raisey D, Tan K, Swatman P, Blackburn T & Nguyen V 2006, "An empirical study of the evolving dynamics of Creative Teams in action"; *Proceedings of the International Conference on Creativity and Innovation in Decision Making and Decision Support*, London, pp. 47-58.

Rakitin, S 2001, "Manifesto elicits cynicism"; *Computer*, pp. 7-9.

Robertson, T 1996, "Embodied actions in time and place: the cooperative design of a multimedia, educational computer game", *Computer-Supported Cooperative Work*, vol. 5, no. 4, pp. 341-367.

Robertson, T 2000, "Building bridges: negotiating the gap between work practice and technology design", *International Journal of Human-Computer Studies*, vol. 53, no. 1, pp. 121-146.

Rooney, D 2005, "Knowledge, economy, technology and society: the politics of discourse", *Telematics and Informatics*, vol. 22, no. 4, pp. 405-422.

Russo, N & Stolterman, E 2000, "Exploring the assumptions underlying information systems methodologies: their impact on past, present and future ISM research", *Information Technology & People*, vol. 13, pp. 313-327.

Sankaran, S & Tay, BH 2007, "Are interpretive and critical research methods useful for research in project management?", *Proceedings of the AIPM National Conference 2007*, Sydney, Australia, pp. 1-13.

Saunders, C, Van Slyke, C & Vogel, D 2004, "My time or yours? Managing time visions in global virtual teams", *Academy of Management Executive*, vol. 18, no. 1, pp. 19-31.

Schmidt, K & Bannon, L 1992, "Taking CSCW seriously", *Computer-Supported Cooperative Work*, pp. 7-40.

Schumpeter, J 1952, *Capitalism, socialism and democracy*, 4th edn, G. Allen & Unwin, London.

Schwartzman, HB 1993. *Ethnography in organizations,* Sage Publications, Newbury Park, London.

Shanks, G, Rouse, A & Arnott, D 1993, "A review of approaches to research and scholarship in information systems", *Proceedings of the Fourth Australasian Conference on Information Systems, Brisbane Australia,* pp. 197-208.

Shumarova, E & Swatman, P 2008a, "Categories of collaboration systems and their organisational impact", *InSyL Working Paper* (May 2008).

Shumarova, E & Swatman, P 2008b, "Informal eCollaboration Channels: Shedding light on 'Shadow CIT'"; *Proceedings of the 21st Bled eCommerce Conference,* pp. 371-394.

Shumarova, E 2009, "Authority–based and bottom–up diffusion of collaboration information technologies: constraints and enablements", *PhD Thesis,* Fachbereich Informatik, Universität Koblenz–Landau, Deutschland.

Smith, AE 2003, "Automatic extraction of semantic networks from text using Leximancer"; *Proceedings of the 2003 Conference of the North American Chapter of the Association for Computational Linguistics on Human Language Technology: Demonstrations,* vol. 4, pp. 23-24.

Smith, AE & Humphreys, MS 2006, "Evaluation of unsupervised semantic mapping of natural language with Leximancer concept mapping", *Behavior Research Methods,* vol. 38, no. 2, pp. 262-279.

Stahl, BC 2005, "A critical view of the ethical nature of interpretive research: Paul Ricoeur and the other", *13th European Conference on Information Systems,* Regensburg, Germany, Paper 29.

Sternberg, R 1999, *Handbook of creativity,* Cambridge University Press, Cambridge.

Sternberg, RJ & Lubart, TI 1993, "Investing in creativity", *Psychological Inquiry,* vol. 4, no. 3, pp. 229-232.

Suchman, LA 1987. *Plans and situated actions: the problem of human-machine communication,* Cambridge University Press.

Suddaby, R 2006, “What grounded theory is not”, *Academy of Management Journal,* vol. 49, pp. 633–642.

Susman, G 1983, “Action research: a sociotechnical systems perspective”, in *Beyond method: strategies for social research,* ed. G Morgan, Sage Publications, London, pp. 95-113.

Suwa, M, Gero, J & Purcell, T 2000, “Unexpected discoveries and S-invention of design requirements: important vehicles for a design process”, *Design Studies,* vol. 21, no. 6, pp. 539-567.

Talbott, SL 1995, “Thoughts on a Group Support System”, in *The future does not compute: transcending the machines in our midst,* ed. SL Talbott, O'Reilly & Associates, Sebastopol, California.

Tan, KL and Swatman, P 2009 “Collaborative team observation and support”, *Proceedings of the IADIS International Conference in ICT, Society and Human Beings,* pp. 98-104

Tang, J, Yankelovich, N & Begole, J 2000, “ConNexus: instant messaging for the workplace”, *Sun Microsystems Laboratories Report,* April 2000.

Tang, J, Yankelovich, N, Begole, J, Kleek, MV, Li, F & Bhalodia, J 2001, “ConNexus to awarenex: extending awareness to mobile users”; *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems,* Seattle, Washington, United States, pp. 221-228.

Terry, M & Mynatt, ED 2002, “Recognizing creative needs in user interface design”; *Proceedings of the 4th Conference on Creativity & Cognition,* Dubrovnik, Croatia, pp. 38-44.

TETQ 2002 “Thanksgiving for innovation”, *The Economist Technology Quarterly,* pp. 13-14.

Thackray, J 1995, “That vital spark (creativity enhancement in business)”, *Management Today,* pp. 56-58.

Torkkeli, M & Tuominen, M 2001, “Use of GDSS in technology selection: experiences and findings”, *Proceedings of the 34th Hawaii International Conference on System Sciences,* pp. 7-13.

Törnqvist, G 2004, “Creativity in Time and Space”, *Geografiska Annaler: Series B, Human Geography,* vol. 86, no. 4, pp. 227-243.

Troyer, L 2003, “Incorporating theories of group dynamics in group decision support system (GDSS) design”, *Proceedings of the International Parallel and Distributed Processing Symposium,* Nice, France, pp. 8-15.

Turban, E, Ma, J & Zhou, D 2004, “A group decision support approach to evaluating journals”, *Information and Management,* vol. 42, no. 1, pp. 31-44.

Turner, BA 1983, “The use of grounded theory for the qualitative analysis of organisational behavior”, *Journal of Management Studies,* vol. 20, no. 3, pp. 333-348.

Turner, R 2007, “Toward agile systems engineering processes”; *Crosstalk,* pp. 11-15.

van der Aalst, WMP, van Dongen, BF, Herbst, J, Maruster, L, Schimm, G & Weijters, AJMM 2003, “Workflow mining: a survey of issues and approaches”, *Data and Knowledge Engineering,* vol. 47, no. 2, pp. 237-267.

van Dongen, BF & van der Aalst, WMP 2004, “EMiT: a process mining tool”; *Application and Theory of Petri Nets,* vol. 3099, pp. 454-463.

Wainfan, L & Davis, PK 2004, *Challenges in virtual collaboration: videoconferencing, audioconferencing and computer-mediated communications,* Rand Corporation, Santa Monica, CA.

Walberg, H and Stariha, W 1992, “Productive human capital: Learning, creativity and eminence”, *Creativity Research,* vol. 5, pp. 323-340.

Wallas, G 1926, *The art of thought,* Harcourt Brace, New York.

Walsham, G 1993, *Intepreting information systems in organisations,* Wiley, Chichester, UK.

Ward, T, Smith, S & Finke, R 1999, “Creative cognition”, in *Handbook of creativity,* ed. R Sternbeck, Cambridge University Press, pp. 189-212.

Warr, A & O'Neill, E 2007, “Tool support for creativity using externalizations”; *Proceedings of the 6th ACM SIGCHI Conference on Creativity and Cognition,* pp. 127-136.

Wasko, M & Faraj, S 2005, “Why should I share? Examining Social Capital and Knowledge Contribution in Electronic Networks of Practice”, *MIS Quarterly,* vol. 29, no. 1, pp. 35-57.

Watson, M, Smith, A & Watter, S 2005, “Leximancer concept mapping of patient case studies”, *Lecture Notes in Computer Science,* vol. 3684, pp. 1232-1238.

Weisberg, R 1999, “Creativity and knowledge: a challenge to theories”, in *Handbook of creativity,* ed. R Sternbeck, Cambridge University Press, pp. 226-250.

Whitman, ME & Woszczynski, AB 2004, "The problem of common method variance in IS research", in *The handbook of information systems research,* eds. ME Whitman, & AB Woszczynski, Idea Group Publishing, Hershey, PA .

Wood-Harper, T 1985, “Research methods in information systems: using action research”, in *Research methods in information systems,* eds. E Mumford, R Hirschheim, G Fitzgerald & T Wood-Harper, NorthHolland, Amsterdam, pp. 169-191.

Yamamoto, Y & Nakakoji, K 2005, “Interaction design of tools for fostering creativity in the early stages of information design”, *International Journal of Human-Computer Studies,* vol. 63, no. 4-5, pp. 513-535.

Yin, RK 2002, *Case study research, design and methods.* Sage, Newbury Park.

Appendix A

A compact disk is included in this thesis showing the raw data collected and the first level of analysis. For each of the three cycles of studies that have been conducted, the following items are included:

1. Version information – date/author of each version of the focal artefact
2. Unprocessed spreadsheets obtained from Leximancer analysis
3. Processed spreadsheets
4. Computation of the delta between two versions of the focal artefact. A programme was designed and used to compute the delta. The programme code is shown in Appendix B
5. Related meeting transcripts

Note that some of the raw data and analysis are not included, e.g. the actual focal artefacts, the email communications etc, because of confidentiality as well as copyright reasons.

Appendix B

In this appendix, we have included the programme to compute the differences in concepts between two versions of the focal artefact.

Programme to show the dynamics between two versions of the focal artefact

‘Version: 1.00;

‘Date: 2 February 2007

‘Developer: Kuan L Tan

‘Description: This programme is designed to be used in Microsoft Excel to compare between two ‘Leximancer-generated spreadsheets. The code will assist the user in finding the most significant ‘changes in the concepts between these two spreadsheets. The user shall insert the first and second ‘Leximancer-generated spreadsheets in Sheet 1 and Sheet 2 respectively. Once this is done, s/he ‘shall execute this programme. The programme will then show the concepts that are changed ‘significantly in Sheet 3. Sheet 4 will display positive concept changes whereas Sheet 5 will display ‘negative concept changes. The sensitivity of the programme (how significant a concept changes ‘before it gets displayed) can be tweaked by changing the value of the variable lngValue. For example, by setting lngValue to 5, the programme will display only the concepts that experience a change in the magnitude of 5 and above.

```
‘Primary subroutine
Private Sub cmdCompute_Click()
'Declare variables
    Dim strSheet1, strSheet2, strTemp As String
    Dim lngPosition As Long
    Dim strPosition As String
    Dim lngCurRows, lngCurCols, lngX, lngY As Long
```

```
'Normalise/Fill the gaps of the spreadsheet
    For lngPosition = 2 To 300
        Call subRowColCopy(lngPosition, "Sheet1", "Sheet2")
    Next lngPosition

    For lngPosition = 2 To 300
        Call subRowColCopy(lngPosition, "Sheet2", "Sheet1")
    Next lngPosition

'Sorting
'Sheet1
    Worksheets("Sheet1").Select
    Rows("2:300").Select
    Selection.Sort Key1:=Range("A2"), Order1:=xlAscending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom, _
        DataOption1:=xlSortNormal
    Columns("B:IV").Select
    Selection.Sort Key1:=Range("B1"), Order1:=xlAscending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlLeftToRight, _
        DataOption1:=xlSortNormal

'Sheet2
    Worksheets("Sheet2").Select
    Rows("2:300").Select
    Selection.Sort Key1:=Range("A2"), Order1:=xlAscending, Header:=xlGuess, _
```

```
        OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom, _
        DataOption1:=xlSortNormal
    Columns("B:IV").Select
    Selection.Sort Key1:=Range("B1"), Order1:=xlAscending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlLeftToRight, _
        DataOption1:=xlSortNormal

'To expand the selection to the current region, we use:
' Selection.CurrentRegion.Select
'To  determine the number of rows in the current region, we use:

' CurRows = Selection.CurrentRegion.Rows.Count
    Selection.CurrentRegion.Select
    lngCurRows = Selection.CurrentRegion.Rows.Count
    lngCurCols = Selection.CurrentRegion.Columns.Count

'Compare and show differences of the values between the two sheets
    For lngX = 2 To lngCurRows
        For lngY = 2 To lngCurCols
            Worksheets("Sheet3").Cells(lngX, lngY).Value = _
                Worksheets("Sheet2").Cells(lngX, lngY).Value - _
                    Worksheets("Sheet1").Cells(lngX, lngY).Value
        Next lngY
    Next lngX
```

```
'Insert concepts on Sheet3
   For lngX = 1 To lngCurRows
      Worksheets("Sheet3").Cells(lngX, 1).Value = _
         Worksheets("Sheet2").Cells(lngX, 1).Value
   Next lngX

   For lngY = 1 To lngCurCols
      Worksheets("Sheet3").Cells(1, lngY).Value = _
         Worksheets("Sheet2").Cells(1, lngY).Value
   Next lngY

'Display positive pairs on Sheet4
   Call subDisplayPositivePairs
'Display negative pairs on Sheet5
   Call subDisplayNegativePairs
End Sub

'Subroutine to add concept-pairs from one worksheet to another
Private Sub subRowColCopy(lngRow2 As Long, strSheet1 As String, _
                  strSheet2 As String)
‘Declare variables
   Dim lngRow1 As Long
   Dim lngCol2 As Long
   Dim strLocation1 As String
   Dim strLocation2 As String
```

```
Dim strTemp As String

'Compare a row in Sheet2 with rows in Sheet1
'See if there are similar rows

strLocation2 = CStr("A") & CStr(lngRow2)

For lngRow1 = 2 To 500 'Worksheets(strSheet1).Rows.Count
   strLocation1 = CStr("A") & CStr(lngRow1)
   If Worksheets(strSheet2).Range(strLocation2).Value _
      = Worksheets(strSheet1).Range(strLocation1).Value Then
      Exit Sub
   End If
Next lngRow1

'Add row to Sheet1
Worksheets(strSheet1).Range(strLocation2).EntireRow.Insert
'Add new concept to row in Sheet1
Worksheets(strSheet1).Range(strLocation2).Value = _
   Worksheets(strSheet2).Range(strLocation2).Value

'Add column to Sheet1
Worksheets(strSheet1).Cells(1, lngRow2).EntireColumn.Insert

'Add new concept to column in Sheet1
```

```
    Worksheets(strSheet1).Cells(1, lngRow2).Value = _
        Worksheets(strSheet2).Range(strLocation2).Value
End Sub

'Subroutine to display positive concept pairs that are above a certain value
Private Sub subDisplayPositivePairs()

‘Declare variables
    Dim lngX, lngY, lngValue, lngCurRows, lngCurCols As Long

'This is the threshold that could be altered
    lngValue = 5

   Worksheets("Sheet3").Activate
    Range("A1").Select
    Selection.CurrentRegion.Select
    lngCurRows = Selection.CurrentRegion.Rows.Count
    lngCurCols = Selection.CurrentRegion.Columns.Count

    'Add the word entity
    Worksheets("Sheet4").Cells(1, 1).Value = _
        Worksheets("Sheet3").Cells(1, 1).Value

    For lngX = 2 To lngCurRows
        For lngY = 2 To lngCurCols
```

```
            If Worksheets("Sheet3").Cells(lngX, lngY).Value >= _
               lngValue Then
                  Worksheets("Sheet4").Cells(lngX, lngY).Value = _
                     Worksheets("Sheet3").Cells(lngX, lngY).Value

                  'Add concept in row
                  Worksheets("Sheet4").Cells(lngX, 1).Value = _
                     Worksheets("Sheet3").Cells(lngX, 1).Value
                  'Add concept in column
                  Worksheets("Sheet4").Cells(1, lngY).Value = _
                     Worksheets("Sheet3").Cells(1, lngY).Value
            End If
         Next lngY
      Next lngX

‘Delete rows/columns that do not display any value
   Call subDeleteEmptyCells
End Sub

'Subroutine to display negative concept pairs that are below a certain threshold
Private Sub subDisplayNegativePairs()

   Dim lngX, lngY, lngValue, lngCurRows, lngCurCols As Long

'This threshold value could be altered
```

```
lngValue = -5

Worksheets("Sheet3").Activate
Range("A1").Select
Selection.CurrentRegion.Select
lngCurRows = Selection.CurrentRegion.Rows.Count
lngCurCols = Selection.CurrentRegion.Columns.Count

'Add the word entity
Worksheets("Sheet5").Cells(1, 1).Value = _
   Worksheets("Sheet3").Cells(1, 1).Value

For lngX = 2 To lngCurRows
   For lngY = 2 To lngCurCols
      If Worksheets("Sheet3").Cells(lngX, lngY).Value <= _
         lngValue Then
            Worksheets("Sheet5").Cells(lngX, lngY).Value = _
               Worksheets("Sheet3").Cells(lngX, lngY).Value

            'Add concept in row
            Worksheets("Sheet5").Cells(lngX, 1).Value = _
               Worksheets("Sheet3").Cells(lngX, 1).Value
            'Add concept in column
            Worksheets("Sheet5").Cells(1, lngY).Value = _
               Worksheets("Sheet3").Cells(1, lngY).Value
```

```
            End If
        Next lngY
    Next lngX
‘Delete rows/columns that do not display any value
    Call subDeleteEmptyCells
End Sub


‘Subroutine to delete unused cells
Private Sub subDeleteEmptyCells()
 ‘Declare variables
    Dim lngX, lngY, lngTemp, lngValue, lngCurRows, lngCurCols As Long
    Dim intCount As Integer

'This is the range that the programme covers when looking for empty cells. The value must be altered if the spreadsheet gets bigger.
    lngCurRows = 250
    lngCurCols = 250

    For intCount = 1 To 10
        For lngX = 1 To lngCurRows
            'Delete empty cells in Sheet4
            If Worksheets("Sheet4").Cells(lngX, 1).Value = _
                Empty Then
                    Worksheets("Sheet4").Cells(lngX, 1).EntireRow.Delete
                    Worksheets("Sheet4").Cells(1, lngX).EntireColumn.Delete
```

```
            End If


            'Delete empty cells in Sheet5
            If Worksheets("Sheet5").Cells(lngX, 1).Value = _
               Empty Then
                  Worksheets("Sheet5").Cells(lngX, 1).EntireRow.Delete
                  Worksheets("Sheet5").Cells(1, lngX).EntireColumn.Delete
            End If
         Next lngX
      Next intCount
End Sub
```

Appendix C

In this appendix, we provide a list of publications that have been produced in line with developing this PhD thesis. Under each publication, a brief overview was provided along with its relations to the thesis.

Blackburn, T, Tan, K, Swatman, P 2009. "Extending a Meeting Model and Identifying Social Activities for Application Support". *IADIS Multi Conference on Computer Science and Information Systems*, pp. 20-27.

Utilising an interesting case study on a meeting held in a car, we have demonstrated the need for support for social processes in any creative-collaborative work. In this paper, we argued that creative team members tend to disregard prescriptive instructions such as agendas, but rather work in a way that was guided by their professional instincts. Due to this fact, there is a difficulty in designing technological support systems for such work. This paper was developed early in the thesis, and set the tone for the rest of our research.

Raisey, D, Tan, K, Blackburn, T, Nguyen V, Swatman, P 2006. "An Empirical Study of the Evolving Dynamics of Creative Teams in Action", *IFIP WG8.3 International Conference on Creativity and Innovation in Decision Making and Decision Support*, vol. 1, pp. 47-55

This is a key paper for this thesis as it forms the first cycle of research. This is where we have initially explored the methodology to develop the dynamics of a Creative Team at work. In particular, we reported a distinctive approach to develop the complexity graph, as well as how to interpret the graph using the team's communication record and post-hoc interview data. This paper served as a foundation for the subsequent two cycles of research, as most of the methodology here was repeated over the course of those cycles.

Tan, KL, Swatman, P, "Modelling Creative Team Dynamics". *43rd Hawaii International Conference on System Sciences 2010*, pp.1-10,

In this paper, we reported the second cycle of research. Promoted as a progression to the first cycle, we observed the case team as they embarked on a subsequent, follow-up project. We repeated the research methodology used in the first cycle, By modelling the dynamics of the focal artefact, analysing communication records and perception data through post hoc interviews, we showed further evidence that creative teams work in a non-linear fashion. Further, we have shown that in a "follow-up" project, a team is less likely to embrace changes in their work, and we explained this phenomenon through the use of the exploration-exploitation theory.

Tan, K., Swatman, P. "Collaborative Team Observation and Support", *IADIS Multi Conference on Computer Science and Information Systems*, pp. 98-104

This paper is developed to describe the implications of the results of the first and second cycles of research of this thesis. We selected particular scenarios that unfolded within the team during the case study observation and discussed how best to support the team in those scenarios. In addition, we emphasized on the belief that a contingency, toolbox-based approach is a viable way forward for creative teams.

Tan, K, Swatman, P, Pethe, A 2009. "Design of a Knowledge Sharing System in a Non-Profit Organisation", *IADIS Multi Conference on Computer Science and Information Systems*, pp. 129-138.

In this paper, we looked at how to develop an effective knowledge repository for a non-profit organisation. Based on interview data and observations, we detailed a step-by-step approach to building the system from the initial stage up to producing a viable prototype. This paper has a minor, yet important role on the thesis, It provides us with a strategy to explore the themes for the future work section in Chapter 7. We hope that the expertise we obtained from system-building activity could assist us to develop a comprehensive support system for Creative Teams.